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REPORTS ON THE SCIENTIFIC RESULTS OF THE EXPEDITION TO THE EASTERN TROPICAL PACIFIC, IN CHARGE OF ALEXANDER AGASSIZ, BY THE U. S. FISH COMMISSION STEAMER "ALBATROSS," FROM OCTOBER, 1904, TO MARCH, 1905, LIEUT.-COMMANDER L. M. GARRETT, U.S.N., COMMANDING.

XXXV.

THE DINOFLAGELLATA: THE DINOPHYSOIDAE.

By CHARLES ATWOOD KOFOID AND TAGE SKOGSBERG.

WITH THIRTY-ONE PLATES.

[Published by permission of Henry O'Malley, U. S. Fish Commissioner].

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I. INTRODUCTION AND COLLECTIONS

This report deals with the pelagic Dinophysoidae, a tribe of the subclass Dinoflagellata, taken by the U. S. Fish Commission Steamer Albatross during an expedition to the Eastern Tropical Pacific, from October, 1904, to March, 1905, under the leadership of the late Alexander Agassiz.

The Mastigophora or Flagellata are represented in the plankton of all seas, and especially in the tropics, by three main groups, called orders in Doflein's (1916) system, namely, the Chrysomonadina, the Dinoflagellata, and the Cystoflagellata. The first-named group is represented by two divergent families, the Silicoflagellidae and the Coccolithophoridae. Owing to their minute size, the Silicoflagellidae are not taken in numbers in the net plankton even with the finest of silk bolting cloths. One must turn to the centrifuge or filter as an effective means of determining the relative abundance of these representatives of the nannoplankton. The natural filters of Salpa and other feeders upon the nannoplankton also offer remarkable resources for observing this group. The calcareous internal skeletal elements of the Coccolithophoridae formed the coccoliths of the mythical "Bathybius" of the reputed primordial slime discovered by the Challenger Expedition. They are retained in calcareous oozes, but the flagellates which produce them, owing to their small sizes, must also be sought in the nannoplankton or in the digestive tracts of animals feeding thereon.

The Dinoflagellata, on the other hand, are of much larger size and are to be found in great numbers in the plankton taken in silk nets, even as coarse as number 12. They are very numerous in most plankton collections, vying with the diatoms for preëminence in numbers and variety. In northern waters the species are less numerous, but the individuals are at times extraordinarily abundant, the total production massive, and their predominance extreme. In the tropics, on the other hand, the number of individuals of any one species is quite generally small, but the number of species is greatly increased and the processes of differentiation reach here their highest expressions.

The Chrysomonadina and the Dinoflagellata are both included in the Phytomastigina, but the Dinoflagellata contain many holozoic genera and species, notably among the Gymnodinioidae. In this tribe also cell-organs such as

ocelli, nematocysts, and tentacles have arisen. Because of these facts and also because of the size and differentiation within the group Kofoid and Swezy (1921) have treated the Dinoflagellata as a subclass coördinate with the Phytomastigina and the Zoömastigina.

The third main group of Flagellata represented in the plankton of the ocean is the Cystoflagellata, containing the widely known genus Noctiluca. This, however, as Kofoid (1919) has shown, is only a highly specialized form of a gymnodinioid dinoflagellate. Since the other representatives of the Cystoflagellata are probably either highly modified dinoflagellates or radiolarians, this group should ultimately disappear from the scheme of classification of the Mastigophora.

The Dinoflagellata are of special interest to the observer of marine life because of their extraordinary power of luminescence. This appears upon stimulation by contact, shock, or chemical irritation, at night only, as shown by experiment. The extent to which luminescence is present among the various dinoflagellates is unknown. It occurs, however, in the Gymnodinioidae in Noctiluca, in the Peridinioidae in Gonyaulax, Ceratium, Blepharocysta, and Peridinium. No critical records of this phenomenon in the Dinophysoidae are known to us, but its occurrence among them is highly probable. Much more remains to be done in relation to the occurrence, location, duration, cause, and nature of the light thus produced in Dinoflagellata generally. These flagellates are also the cause of the notorious outbreaks of "red water" in tropical and warm-temperate seas (Torrey, 1902, and Kofoid, 1911) in which the enormous numbers present give a reddish, brownish, or yellowish discoloration to the surface waters, often for long distances along shore, or in great areas of the off-shore tropical currents.

The collections of the Expedition have been found to contain 132 species of Dinophysoidae, including 82 new species and four new genera. All but one of the known genera are represented or occur in the area traversed by the Expedition and 132 of the 198 known species, or 66.7%, occur in the Expedition material. The species not recorded are mainly those restricted to colder regions or they are very rare tropical forms. The report upon the tribes Gymnodinioidae and the Peridinioidae of this Expedition is in the course of preparation.

The Dinophysoidae are marine and widely distributed in the plankton of coastal waters and in the uppermost 300 fathoms of the illumined zone of the high seas in all latitudes. The species of this group are remarkable for their diversity, for their occasional brilliant coloring, and for the extraordinary evolution of organs of flotation in the form of processes of the body or in the form of

lists differentiated as parachutes, sails, wings, or rudders. The thecal wall or cuirass which forms the surface of the body retains throughout the whole group the structural simplicity in the matter of the numbers of its constituent plates found in the simplest and most primitive members. It is bivalved and each valve contains three elements, an epithecal, a cingular, and a hypothecal plate. In certain genera such as Dinofurcula, Amphisolenia, Triposolenia, and in a few of the more divergent tropical species of Dinophysis, the body, while retaining its bivalved simplicity of component parts, undergoes a remarkable evolutionary flare of elongation, bifurcation, multiple branching, and distal twisting into asymmetrical form, all of which serve the function of flotation. In this assemblage of species in which the body proper undergoes these extensive diversifications in form, there is very little evolution of the lists of the girdle and the sulcus.

Since the Dinophysoidae are predominantly, if not wholly, either photosynthetic, or associated with commensal photosynthetic phaeosomes, they find their optimum conditions of life within the lighted zone in the upper levels of the sea. Adaptations to flotation and to hydrostatic adjustments thus loom large in their structural evolution. The structural expansions of the surface lend themselves to regulatory control by resorption, especially at binary fission, and to extension by renewed outgrowth to meet diverse conditions of the environment.

Acknowledgments

No investigation involving so extensive collections, so prolonged search of the diversified constituents of the tropical marine plankton, so much drawing and sketching for purposes of record and comparisons, and the use and clerical analysis of so widely scattered a literature, can be brought to completion without the collaboration of several workers.

During the Cruise the senior author made daily observations and notes on the plankton as collected, and throughout the work has continued in close collaboration in the microscopical, morphological, and systematic analysis of the material. He has resolved the structure of the individuals utilized in the elaborately finished drawings, and supervised the completion of the illustrations. He is responsible for the plan of the work, of the method of treatment of species, and jointly with Dr. Skogsberg for the morphological analysis and systematic arrangement of the text.

The manuscript of Part II of the work has in the main been prepared by Dr. Skogsberg, with the continuous collaboration and joint analysis of all moot points with the senior author.

The original drawings and records of occurrences based on the painstaking examination of the plankton collections are the work of Mrs. Michener from May 1905 to June 1908, and from June 1909 to July 1910. Her sketches have been utilized in the text figures and her detailed drawings, finished in pencil, have been transferred and prepared for reproduction on Ross board by Mr. A. B. Streedain. His skill in portraying contour and detail by this method has contributed much to the accuracy and beauty of the plates.

We are indebted to the late Dr. Alice Robertson for assistance in organizing the multitudinous details of several of the genera.

For grants in aid of the work we are also indebted primarily to Alexander Agassiz, who after the close of the Cruise continued to manifest a deep interest in the progress of the work; and to the Carnegie Institution of Washington, through the late Dr. Alfred G. Mayor, Director of the Department of Marine Biology, for a grant for assistance in the preparation of the manuscript.

The work could not have been completed except for substantial grants made by the Board of Research of the University of California for the past four years.

Methods of Collecting

The plankton collections were made, in the main, by the following methods:— Under normal conditions, except on the Manga Reva-Acapulco line, a collection was made each evening at 8 P.M. with number 12 and number 20 silk nets towed from the port boom on either side of the large 000 plankton net. The depth at which these nets fished was generally within the uppermost fathom. The nets were out for about twenty minutes.

The same nets were used in the morning collections at 8 A.M., but at this time sufficient cable was payed out to lower them to a depth of 300 fathoms. They were towed for twenty minutes, steaming slowly, and were then hauled in. They were open and fishing during both descent and ascent and the catch therefore represented the plankton from all levels traversed by the nets, but mainly from the level at which they were towed for twenty minutes, since the total time of lowering and hoisting was not more than one third of the time of towing at the lower level.

As a rule the number 12 and number 20 nets were attached to the cable when hydrographic samples were taken at a depth of 800 fathoms. These catches are thus from a vertical column of water from this depth to the surface.

On the line from San Francisco to Panama collections were made in vertical

hauls with the number 12 and number 20 nets attached in series to a vertical bar lashed to the cable. This method was abandoned after leaving Panama.

The plankton nets used in these collections were of the Kofoid (1898) type, of number 12 and number 20 Dufour silk bolting cloth respectively, fourteen inches in diameter at the top, five feet in length, with a brass bucket at the lower end. Two such nets may be cut readily from two yards of silk and are of a size convenient to handle. They have a surface for filtration of such proportions to the opening that the coefficient of filtration is low.

These plankton collections made regularly in course of the routine of the Cruise were supplemented from time to time by wing-net catches taken in small nets (four inches in diameter) tied to the upper bars of the runners of the trawl when trawling. These catches contain samples of plankton from bottom to surface, since they were so suspended as to fish during both descent and ascent as well as while trawling.

An attempt was also made to utilize a silk filter connected with the ship's circulating system near the intake and running continuously during the Cruise. A number 20 silk net with a fourteen-inch opening was suspended in a vertical cylinder with suitable overflow for the filtered water. This net received a continuous stream from a pipe tapped into the circulating system within twenty feet of the intake. It functioned satisfactorily for the first fortnight, but its efficiency was destroyed by the accumulation of attached plankton-feeding organisms, principally barnacles, as shown by their faeces and remnants, which grew along the pipe line and so reduced the plankton in amount as to render the catches of little significance. Iron rust and the quick disintegration of the silk net in the warm waters of the tropical seas also added to the inefficiency of this method. Catches were made by this method for over half of the Cruise, but their contents are meager and add nothing of value to the material.

Local surface and a few short vertical hauls with the number 12 and number 20 nets were made in the harbors at Panama, Manga Reva, and Acapulco. Conditions at Callao, at Chatham Island in the Galapagos, and at Easter Island respectively were so similar to those of the environing ocean that local collections at these points were of no great significance. In the main these local collections added little to the material of the Dinophysoidae, since they were remarkably poor in organisms of this group except for a few of the hardier types which were invariably found also in the coastal waters.

As will be seen in the station lists our main resources were in the regular hauls from the surface and from 300–0 fathoms, especially in the latter, which,

as a rule, have a wider range of species since they contain the contributions from practically all zones in which dinoflagellates normally live. The catches of the wing-nets from the greatest depth and those at the hydrographic stations from 800 fathoms contained no additional Dinophysoidae not found in hauls from 300 fathoms and no noticeable change in the proportionate representation of the species.

Distribution of Collections

The collections were taken at 127 stations on the Cruise. A list will be found in Part III, together with the pertinent data. A fuller account appeared in the General Report of the Cruise by Mr. Agassiz (1906). Their distribution on the six lines of the Expedition is shown in Plate **24**. Stations 4571 to 4627 are on the San Francisco-Panama line, 4631–4671 on the Panama-Callao line, 4673–4692 on the Callao-Easter Island line, 4694–4716 on the Easter Island-Galapagos line, 4717–4739 on the Galapagos-Manga Reva line, and 4740–4746 on the Manga Reva-Acapulco line.

The collections at regular stations number 225. Of these eighty-three are from the surface, twenty-four more from Salpa stomachs treated as from the surface, ninety-four from 300–0 fathoms, twenty from 800–0 fathoms, and four from various other depths to the surface. The surface hauls, those from Salpa, and those from deeper levels are distributed on the six lines of the Expedition as follows: — on the (first) San Francisco-Panama line, 19, 2, and 19; on the (second) Panama-Callao line, 21, 5, and 29; on the (third) Callao-Easter Island line, 11, 2, and 15; on the (fourth) Easter Island-Galapagos line, 13, 6, and 19; on the (fifth) Galapagos-Gambier line, 9, 6, and 31; and on the (sixth) Gambier-Acapulco line, 10, 3, and 5, respectively. In addition to these from the surface, from Salpa, and from the deeper levels there were incidental plankton collections at the anchorages at Panama, off Easter Island, and in the harbor at Acapulco, Mexico. These are, however, utilized only incidentally and are not treated as regular stations of the Cruise.

The few collections made with the Chun plankton closing net are also omitted as they add nothing of systematic significance to the Dinoflagellata from the other collections.

The distribution of the pelagic stations in the several oceanic currents is shown in detail in the following table: —

DISTRIBUTION OF PELAGIC STATIONS

	Total number of stations	Surface and vertical	Surface only	Total of vertical	Total of surface
California Current	4	4	..	4	4
Mexican Current	13	1	8	5	9
Panamic Area	17	2	11	6	13
Peruvian Current	27 [1]	15	5 [1]	22	20 [1]
Easter Island Eddy	10	..	5	5	5
Galapagos Eddy	4	..	2	2	2
South Equatorial Drift	45	1	22	23	23
South Equatorial Current	3	..	2	1	2
Equatorial Counter Current	2	..	2	..	2
North Equatorial Current	2	..	2	..	2
	127	23	59	68	82

[1] One of these is from Salpa only.

Examination of Collections

The plankton catch, as soon as it arrived on board ship, was released from the bucket into glass sorting dishes, treated with chloretone for anaesthetizing the larger organisms, and promptly fixed in 10% formalin. The plankton consisted of the fine sedimented residues remaining after the larger organisms such as the Coelenterata, larger Copepoda, Amphipoda, pelagic Mollusca, Tunicata, and larval fishes were removed. Small amounts were occasionally preserved in various fixing agents. This Report is, however, based on the formalin material since formalin, far better than any other fluid, preserves and reveals the skeletal structures upon which in final analysis the systematic relationships are based, and in which individual variations are revealed.

The collections were examined in the original sea-water and formalin without other treatment than replacing the loss by evaporation with distilled water in some cases. It is thus often possible to roll the organisms about under the cover-glass and to secure diverse views in many cases of the same individual, and sometimes also to shatter it into its constituent plates when this is necessary. The method has the disadvantage of not making it possible to reëxamine the same individual with certainty a second time. There is, unfortunately, no safe and certain method of sealing permanent microscopical mounts in formalin. Whenever it was desired to isolate some special individual organism, the material under the cover-slip was washed carefully into a vial instead of into the general catch. The type specimens and cotypes are thus preserved.

After a sufficient knowledge of the more abundant species had been acquired, each catch was searched by use of the mechanical stage until no additional species

were detected. The lists of occurrences at the record stations were thus made up. The station lists (Part III) incorporate these data as modified by all later more critical revision.

In order to have at least a quasi-quantitative record of *relative* frequency in individuals of the component species of each catch, records were made during the search of each collection of the number of individuals seen of each species, up to the total of the first one hundred individuals seen. Thereafter each additional species detected at that station was merely recorded as "also present." The number of individuals recorded is thus the percentage frequency at that station. These numbers have been used in mapping the local distribution of the genera. The numbers are recorded in Roman numerals at the ends of the radii from the circles marking the locations of stations on the route (Plate 24).

The records of relative frequency used in the discussions of the distribution of each species, thus refer solely to the relative numbers of the different species in the one catch and give no indication of relative numbers of the species in question in different catches.

The data thus accumulated have involved certain difficulties and discrepancies, especially in those cases in which a species, originally conceived in the wider sense, was later in the preparation of the manuscript broken up into several species by the withdrawal of divergent groups. In all such cases only those individuals which had been drawn were perforce included in the groups thus segregated off. All others recorded in the original analysis were left under the original specific name in the later restricted sense.

The concept of each species in the inception of the work of necessity rested upon previously published figures or upon the characters of the first individual whose structures were analyzed and from which the first figures were made. As the allocating of the individuals to definite species progressed, our concept was widened or modified by the detection of variants from the figure of the type individual. To meet this condition and to make available for purposes of comparison the structure of individuals of the same species from different localities, it became necessary to sketch the outline of the most apparent and easily determined parts of an ever-increasing number of individuals. This was especially true in most cases of the more abundant and generally more widely varying complexes. These groups of sketches constituted the great mass of data on which the manuscript has been based, and they form the sources of the text figures which illustrate the range of variability and the aberrant types which are included within our concept of the several species.

The fact should be noted that these habitus sketches represent the range of variation observed and not the normal distribution within that range. The constant tendency quite naturally in the premises was to make graphic record of *all the aberrant* individuals even though these constituted only a very small proportion of the total representatives of the species. It thus follows that the diversity in the few individuals within the species is emphasized rather than the uniformity among the many.

Number of Genera and Species

The microplankton of the Expedition contains a total of 132 species of Dinophysoidae. No less than eighty-eight new species have been established in connection with this Report. Of these new species thirty-two were described by Kofoid (1907a), twenty-nine by Kofoid and Michener (1911), and twenty-seven are described in the present paper. Of these twenty-seven species, twenty-six were found in the material of the Expedition; one (*Phalacroma paulseni*, p. 60) was based on a figure published previously (Paulsen, 1911b, p. 305, fig. 2). The following is a list of the new species found in the material of the Expedition:

Described in Kofoid (1907a)

Phalacroma
- lenticula
- reticulatum
- striatum

Dinophysis
- triacantha

Amphisolenia
- asymmetrica
- bispinosa
- brevicauda
- clavipes
- curvata
- extensa
- laticincta
- lemmermanni
- palaeotheroides
- projecta
- quadrispina
- quinquecauda
- rectangulata
- schröderi

Dinofurcula (as Phalacroma)
- ultima

Triposolenia
- longicornis
- fatula
- ambulatrix

Ornithocercus
- carolinae
- heteroporus

Parahistioneis (as Histioneis)
- garretti
- reticulata

Histioneis
- carinata
- josephinae
- longicollis
- navicula
- paulseni
- pulchra

In Kofoid and Michener (1911)

Phalacroma
- circumcinctum
- expulsum (as Dinophysis)
- favus
- fimbriatum
- giganteum
- limbatum
- porosum
- praetextum
- pulchrum
- turbineum

Dinophysis
- collaris

Histiophysis (as Dinophysis)
- rugosa

Amphisolenia
- astragalus
- quadricauda
- truncata

Ornithocercus
- truncata
- orbiculatus

Parahistioneis (as Histioneis)
- diomedeae
- karsteni
- rotundata

Histioneis
- costata
- elongata
- hippoperoides
- hyalina
- inclinata
- inornata
- panda
- reginella
- striata

Described in this Report

Heteroschisma
aequale
inaequale
Phalacroma
apicatum
bipartitum
contractum
cuneolus
lativelatum
lens
mucronatum
protuberans
pyriforme
Dinofurcula
ventralis
Dinophysis
exigua
jörgenseni
monacantha
okamurai
similis
swezyi
trapezium
urceolus
Amphisolenia
complanata
elongata
Triposolenia
intermedia
Parahistioneis
paraformis
Histioneis
pacifica
panaria

Besides the new species mentioned above, the following new specific and subspecific names are introduced in this Report: —

Dinophysis baltica (p. 229) for *D. ovum* Schütt var. *baltica* Paulsen (1908)

Dinophysis caudata f. *acutiformis* (p. 227) for *D. homunculus* var. *ventricosa* Pavillard (1916)

Dinophysis recurva (p. 228) for *D. lenticula* Pavillard (1916)

Dinophysis reniformis (p. 228) for *D. pavillardi* Schröder (1906a)

As shown in the following table there are in all fourteen genera, of which five are new.

	Total number of specific and subspecific names established in literature	Number of valid species and subspecies	Number of new species and subspecies described in connection with this Report	Total number of species and subspecies found by the Expedition
Thecadinium, gen. nov.	2	2	..	..
Pseudophalacroma	1	1	..	..
Oxyphysis	1	1		.
Heteroschisma, gen. nov.	2	2	2	2
Phalacroma	73	50	23	31
Dinofurcula, gen. nov.	2	2	2	2
Dinophysis	123	52	10	20
Histiophysis, gen. nov.	1	1	1	1
Amphisolenia	32	31	19	26
Triposolenia	9	9	4	8
Ornithocercus	16	8	4	9
Parahistioneis, gen. nov.	9	9	6	7
Histioneis	45	28	17	24
Citharistes	2	2	..	2
Totals	318	198	88	132

Of the five new genera, four — viz., Heteroschisma, Dinofurcula, Histiophysis, and Parahistioneis — are based on species found in the material of the Expedition; one, Thecadinium (p. 32), was founded on two previously described species, *Amphidinium kofoidi* var. *petasatum* Herdman (1922, p. 26) and *Phalacroma ebriola* Herdman (1924, p. 34).

Up to April 1, 1926, there have been described 318 species and subspecies in the Dinophysoidae. Of these only 198 are regarded as valid. Of the 198 valid species 132 or 66.7% of the known species were found in the collections of the Expedition. The eighty-seven new species constitute 65.9% of the total number (132) found on the Expedition, and an increase of 80% to the 111 species previously known. This has resulted from the large representation of the rich tropical fauna in the collections and from the intensive search of the richer plankton collections and of the contents of Salpa stomachs for the rare and often minuter species.

The accompanying table records under each genus the number of species and subspecies in literature, the numbers of these which in our opinion, with some reservations, are to be considered valid, the numbers of new species established in connection with this Report, and the total numbers of species found in each of fourteen genera.

Orthogenesis and Convergence

The species are arranged within the genera according to their structural resemblances, upon the assumption that the degrees of structural resemblances are indications of commensurate degrees of genetic relationship. It is fully realized that such resemblances may, however, not be accurate quantitative measures of the degrees of genetic relationship, or unequivocal demonstrations of genetic origins. Nevertheless they are the only evidences of the nature and results of the evolutionary process in this highly diversified group, and while their quantitative value may well be quite hypothetical, their qualitative significance is undoubtedly of high value in showing the method, direction, and trend of the evolutionary process in the group.

The record is all the more definite and clear because of the fact that it is registered in the non-mobile exoskeleton or theca of the body and its outgrowths. While it is true that the more superficial structures such as lists, fins, and sails are subject to regulatory modifications and to considerable individual variation, we nevertheless find beneath such variation the more basic similarities and differences, which may serve as guides in the establishment of genetically related groups.

The groups of species thus established within the genera exhibit relationships in structure among themselves which make feasible their grouping in a dendritic, diverging fashion, suggestive of phylogenetic descent.

Within the subgenera or other secondary groups of several of the genera, the known species, even though there be but a few, may usually be arranged in

something of an orthogenetic fashion according to the degree of specialization of one or more structural features, in ascending series from the simpler to the more complex. These series, which are not always equally spaced, are orthogenetic, since they appear to exhibit progressive (or regressive) movements in their evolution or speciation.

The orthogenetic tendencies within these lines may be summarized as (*1*) increase in size; (*2*) increase in relative length, especially in Amphisolenia and Triposolenia; (*3*) branching or extensions of the body, as in Amphisolenia and Dinofurcula; (*4*) increase in the development of the reticulations on the surface of the theca, often by heavier ribbing and larger size of the reticulations; (*5*) extension and ribbing of the anterior and posterior cingular lists about the girdle culminating in *Ornithocercus splendidus* and *Histioneis josephinae;* (*6*) extension and structural modifications of the right and left sulcal lists, as in Histioneis; and (*7*) the progressive elaboration of the phaeosome chamber in Ornithocercus, Histioneis, Parahistioneis, and Citharistes.

The net result of our analysis of the process of speciation in the Dinophysoidae has been a growing conviction that there is in this group a more or less orderly divergence from primitive species with a small, spheroidal body, with a smooth undifferentiated surface, low, simple cingular and sulcal lists, and no phaeosome chamber, toward the more elaborate types along a number of divergent lines. Furthermore the progress of this process of evolutionary divergence is marked to a surprising degree by an orthogenetic aspect. The evolutionary steps seem to be represented in living Dinophysoidae, at least to such a degree that the path presumably followed in the process is still indicated by them. It may be that they represent only laterals along this path, but these still-existing types have seemingly remained near enough to their levels of divergence from the main paths to mark their courses.

A striking feature is that the process of speciation has proceeded in this group to a marked degree of specialization in the seeming absence of sexual reproduction. There is as yet no evidence of the occurrence of this mode of reproduction in the Dinophysoidae.

Another striking feature of the evolution of the Dinoflagellata is the fact that there is no evidence of closely related species being isolated from each other either geographically or bathymetrically. Both the most primitive and the most divergent and highly specialized genera and species occur together in the same region, and very closely related forms are not infrequently recorded in the same surface catch or from the same Salpa stomach. Specific adaptations to zones of illumi-

nation and temperature undoubtedly exist, but diurnal migrations in heliotropic responses to the rhythm of solar energy and to other cosmic and meteorological factors may be expected to produce some vertical extension of the zones inhabited by each species, and to vary these extensions with changing conditions. Save for the larger differences due to latitude and depth, areal distribution affords little aid in the solution of evolutionary problems. Along broad lines the species are widely distributed in all seas in waters of comparable temperatures and illuminations. The ecologic niche which each fills is in reality a wide shelf girdling the tropical seas and extending to a considerable depth. Moreover, many of these areas of distribution appear to be to a large degree coincident, even within the species of a single orthogenetic line. The factor of geographical isolation, so significant among birds and mammals in which feeding range and sexual behavior so immediately affect the genetic processes and evolutionary progress, sinks into relative insignificance, if indeed it ever had any considerable part, in the process of speciation among the Dinophysoidae.

It is also interesting to note that the most highly specialized genera such as Citharistes and Histioneis and the most highly specialized species within the genera, are, in the main, relatively rare in individuals. The development of adaptive structures of a highly specialized type is not in many instances accompanied by a corresponding reproductive vigor or equal enlargement of survival value.

Attention may also be invited to another phenomenon of evolutionary significance which has emerged in the analysis of the Dinophysoidae, namely, the appearance in Heteroschisma and Pseudophalacroma of a structural character identical in location and morphological relations with a fundamental structural feature of the Peridinioidae. This character in Heteroschisma is the marking out by structural lines of an area corresponding to plate 1 of the postcingular series of the latter tribe.

The Peridinioidae differ from the Dinophysoidae in the facts that the skeletal elements of the former are (*1*) in five (or six) instead of three horizontal zones and (*2*) that the pre- and postcingular zones have five instead of two plates or elementary subdivisions. It is a striking fact that the postcingular zone of Heteroschisma has developed the structural features of the first plate of the postcingular series next to the flagellar pore, sulcus, and blepharoplast (see Hall, 1925). This is illustrated in detail in the discussion of *Heteroschisma aequale* and *inaequale* (Plate 1). In the genus Pseudophalacroma there are evidences of a comparable emergence of a structural field homologous in morphological rela-

tions with plate 1 of the precingular series and also located near the flagellar pore. Both of these genera are among the less specialized members of the tribe, although the species of Heteroschisma have a somewhat advanced development of the surface.

The phenomenon here observed is of the same category as that described by Kofoid (1926) in *Oxyphysis oxytoxoides*, in which a rather highly specialized genus, Oxyphysis, of the Dinophysoidae, has the facies of Oxytoxum, of the Peridinioidae. In the cases of Heteroschisma and Pseudophalacroma the convergence of characters is found in a single one of the plates or unitary elements of the skeleton. In the case of Oxyphysis it appears in the external form of the body as determined by the total skeleton, the location of the girdle and sulcus, and the shaping of the two apices. These three instances of convergent features of structure between the Dinophysoidae and the Peridinioidae lead strongly to the inference that the structure of the species or larger systematic category, as well as that of the individual, may not wholly reveal its genetic potentialities. The Dinophysoidae appear to carry potentialities of producing in the course of their evolution, in these three genera only, so far as is known, certain structural features which belong primarily in the tribe Peridinioidae and are characteristic of it, in the case of the plate of Heteroschisma and Pseudophalacroma, or of a single genus in the tribe, as in the case of Oxyphysis.

Procedure used in the Accounts of Genera and Species

Nearly all the descriptions of genera, species, and subspecies published up to the present time are short and incomplete, with but few data concerning the nature and amplitude of variation. Ours is the first attempt at a more or less exhaustive treatment of the various systematic units. A consequence of this is that we have had to elaborate a new technique of description and treatment. Our basic principle is to keep everything that implies comparisons as stereotyped as possible in order to obtain the greatest possible perspicuity and ease of comparison and reference. A usual shortcoming of current taxonomic papers is that the various systematic descriptions are not treated in a consistent arrangement and manner. Frequently it is necessary to traverse a mass of facts in order to find the one that is desired. In short papers this defect may be more or less inconsequential, in large monographs and in genera with numerous species it creates almost insuperable difficulties and an annoying loss of time. In the present paper each character has the same relative place in all of the diagnoses and descriptions and in so far as possible is discussed in the same phraseology.

The families have been treated under the following headings: — (*1*) Diagnosis; (*2*) Subdivisions. Relationships among the genera; (*3*) Distribution; (*4*) Key to the genera.

In the case of the genera the following arrangement has been adopted: — (*1*) Synonyms; (*2*) Diagnosis; (*3*) Organology; (*4*) Reproduction; (*5*) Distribution; (*6*) Historical discussion; (*7*) Adaptive and systematic value of the characters. Principles used in the descriptions of the species; (*8*) Subdivisions. Relationships among the species; (*9*) Key to the species.

These are the subheadings under each species: — (*1*) Synonyms; (*2*) Diagnosis; (*3*) Description; (*4*) Dimensions; (*5*) Variations; (*6*) Comparisons; (*7*) Synonymy; (*8*) Occurrence.

On account of the fact that the various genera are quite decidedly different morphologically, it is impossible to apply the same procedure of description to all of them. The differences in descriptive technique are, however, not very great and inside each genus the treatment conforms to the type established. In the general account of most genera a diagrammatic figure elucidates our terminology and methods of measuring proportions and angles.

At the end of the description of each species information is given as to the number of specimens, the proportions of which were measured. With the exception of the length of the body, all statements as to proportions and dimensions refer to these specimens only. The following random example: — "the posterior cingular list is 0.50 (0.49–0.53) the length of the body from the apex" should be understood as follows: — the figures inside the parenthesis indicate the range of variation; the figure in front of the parenthesis, the average. This average is not weighted and based on random sampling, but is the average of the drawings which are based on selected specimens, some of which were "typical," others more or less extreme and selected because of their departure from the norm.

In describing curves: — gently, moderately, and strongly (or boldly) convex or concave indicates an increasing degree of convexity or concavity (quantitative); in order to express an increasing uniformity of curvature, the terms irregularly, somewhat irregularly, subuniformly, and uniformly convex or concave (qualitative) are used.

In recording the species all the samples from the same depth are counted as a single record; for instance, if a species is found at one station in two or more samples from 300 fathoms to the surface, all these records are considered as one. In the accounts of the distribution of the species, according to previously published literature, the material is arranged geographically. Beginning with the

data from the northern Atlantic Ocean we proceed south to the Antarctic Ocean; then the data from the Mediterranean, proceeding from the west to the east; from the eastern Mediterranean we proceed through the Red Sea, the Gulf of Arabia, the Indian Ocean, Antarctic Ocean, Malay Archipelago, Australian waters, Chinese and Japanese waters, and finally in an easterly direction across the Pacific Ocean.

II. SYSTEMATIC ACCOUNT

Classification

Phylum 1. Protozoa Goldfuss
  Superclass 1. Plasmodroma Doflein
    Class 1. Mastigophora Diesing
      Subclass 1. Dinoflagellata Bütschli
        Order 1. Adiniferidea Kofoid and Swezy
          Tribe 1. Athecatoidae Kofoid and Swezy
          Tribe 2. Thecatoidae Kofoid and Swezy
        Order 2. Diniferidea Delage and Hérouard emend.
          Tribe 3. Gymnodinioidae Poche emend.
          Tribe 4. Amphilothoidae Kofoid and Swezy
          Tribe 5. Peridinioidae Poche emend.
          Tribe 6. Dinophysoidae Kofoid
            Family 1. Dinophysidae Stein emend.
              Genus 1. Thecadinium, gen. nov.
                2. Pseudophalacroma Jörgensen
                3. Oxyphysis Kofoid
                4. Heteroschisma, gen. nov.
                5. Phalacroma Stein
                6. Dinofurcula, gen. nov.
                7. Dinophysis Ehrenberg
                8. Histiophysis, gen. nov.
            Family 2. Amphisolenidae, fam. nov.
              Genus 9. Amphisolenia Stein
                10. Triposolenia Kofoid
            Family 3. Ornithocercidae, fam. nov.
              Genus 11. Ornithocercus Stein
                12. Parahistioneis, gen. nov.
                13. Histioneis Stein
            Family 4. Citharistidae, fam. nov.
              Genus 14. Citharistes Stein

DINOPHYSOIDAE

"der Dinophysiden" Stein, 1883, p. 23.
Dinophysida Bütschli, 1885, p. 1009.
Dinophyseae Schütt, 1896, p. 26.
Dinophysidae Doflein, 1909, p. 464; 1911, p. 530; 1916, p. 436; Kofoid & Michener, 1911, p. 268; Lebour, 1925, p. 75.
Dinophysiaceae Pavillard, 1916, p. 44; Jörgensen, 1923, p. 3.
Dinophysaceae Oltmanns, 1922, p. 54.
Dinophysoidae Kofoid, 1926, p. 215.

Diagnosis:— Dinoflagellata with well-developed girdle and sulcus, with permanent longitudinal and transverse flagella located respectively in sulcus and girdle, with a single flagellar pore located in sulcus, and with body surrounded by theca composed of two subequal halves joined approximately in sagittal plane and, as a rule, made up of but three plates, epithecal, cingular, and hypothecal. Girdle usually anterior in position.

Exclusively marine.

Derivation. Subdivisions. Relationships among the Families

While several investigators have united the dinophysids and the peridiniids (*e.g.*, Lebour, 1925), we have adopted Kofoid's (1926) decision that they form two separate tribes, viz., Dinophysoidae and Peridinioidae, and have done so on account of the fundamental structural differences and because of the fact that all available evidence appears to support the opinion expressed in the pedigrees of the dinoflagellates constructed by Bütschli (1885, p. 1016) and Kofoid and Swezy (1921, p. 84), viz., that these groups have evolved independently from the tribe Gymnodinioidae.

In all the discussions of the interrelationships of the various taxonomic units of Dinophysoidae, we have (contrary to Kofoid and Swezy, 1921, p. 84) adopted the viewpoint that this tribe evolved from ancestral forms very closely resembling *Gymnodinium ovulum* Kofoid and Swezy (1921, pl. 5, fig. 58). These ancestral forms might be characterized briefly in the following manner:— (*1*) body small and spheroidal, its length, depth, and width subequal; (*2*) girdle subequatorial, its distal portion not displaced; (*3*) sulcus short on both epitheca and hypotheca; (*4*) cingular and sulcal lists small and structurally undifferentiated; (*5*) without accessory lists or sails. Small size and subrotund shape of body are features characteristic of the simply organized members of most of the genera of Dinophysoidae, *e.g.*, Heteroschisma, Phalacroma, Dinophysis, Ornithocercus, Parahistioneis, and Histioneis. It is an almost universal rule in this

tribe that the increase in structural complexity is accompanied by an increase in size. The distal portion of the girdle is displaced only in one of the known species of Dinophysoidae, viz., in *Dinofurcula ultima* (Plate 5, fig. 4, 6). The shortness of the hypothecal sulcus is a characteristic of most genera, and its anterior prolongation occurs but seldom and only in genera (Pseudophalacroma, Oxyphysis) which show other indications of primitiveness. There is within most of the large genera a distinct tendency for the cingular and sulcal lists to increase in size and structural complexity; and accessory lists and sails occur only in a few genera and very seldom in the simply organized members of these. The assumption that the girdle originally was equatorial in position is somewhat more uncertain than the others. In Gymnodinioidae this structure has no fixed position but may be found anywhere between the apex and the antapex; in Amphidinium it is anterior, in Gymnodinium more or less equatorial, and in Torodinium posterior. In Dinophysoidae, on the other hand, it is either subequatorial or more or less anterior. The reasons for assuming the equatorial position as the most primitive in Dinophysoidae are as follows:— (*1*) the girdle is anterior in all the more or less highly differentiated families, viz., in Amphisolenidae, Ornithocercidae, and Citharistidae, and Histioneis, the most complex of all the genera of this tribe, is characterized by a smaller epitheca than any other genus; (*2*) in the Dinophysidae the epitheca is small in the two most differentiated genera, viz., Dinophysis and Histiophysis, and relatively large in most of the more or less primitive genera, Pseudophalacroma, Oxyphysis, Heteroschisma, and Phalacroma. The only striking exception to this rule is Thecadinium, and this genus is of uncertain systematic position and probably did not develop from the same ancestral forms as the rest of the family, but from Amphidinium-like forms.

The genera of the tribe Dinophysoidae are assigned to one of the four families, viz., Dinophysidae, Amphisolenidae, Ornithocercidae, and Citharistidae, all of which are either new or emended. As to the interrelationships of these four families but little can be said with any degree of certainty. The Dinophysidae comprises the structurally simplest members and presumably evolved directly from Gymnodinioidae. Amphisolenidae may have sprung from the same ancestral forms of Dinophysis which evolved into *Dinophysis caudata* and *D. miles* and which were characterized by the tendencies toward elongation, attenuation, and posterior bifurcation. Ornithocercidae presumably evolved from some ancestral forms closely related to Phalacroma, Dinophysis, and Histiophysis. Citharistes approaches Dinophysis in the shape and size of the anterior cingular

and the sulcal lists. It differs strikingly from this genus in the differentiation of the dorsal portion of the girdle into the large phaeosome chamber. This chamber probably originated by a gradual increase in the dorsal width and concavity of the transverse furrow, such as can be seen in the genus Parahistioneis (*cf.* for instance, *P. reticulata*, Plate 19, fig. 7).

1. DINOPHYSIDAE Stein, 1883, emend.

Diagnosis: — Body of diverse shapes; ratio between length and depth usually somewhere between 1.0:1 and 1.7:1. Epitheca small, disk-like to large, sometimes even as large as hypotheca. Transverse furrow narrow and, as a rule, about as wide dorsally as ventrally; its dorsal width less than 0.30 the greatest depth of body. Cingular lists, when present, subhorizontal or inclined anteriorly, narrow or of moderate width, usually less than 0.30 the greatest depth of body. Phaeosomes occur only in one genus. Length of body, 21–148 μ.

Marine, usually eupelagic, in all seas.

Subdivisions. Relationships among the Genera

Dinophysis Ehrenberg (1840a), the type genus of Dinophysidae, was the first genus of the family to be established. Later Phalacroma was introduced by Stein (1883), Pseudophalacroma by Jörgensen (1923), and Oxyphysis by Kofoid (1926); and in the present paper four new genera, viz., Heteroschisma, Dinofurcula, Histiophysis, and Thecadinium, are described. Of these eight genera, Phalacroma and Dinophysis are by far the largest, the former comprising forty-seven, the latter forty-one presumably valid species. Pseudophalacroma was founded on a single species previously assigned by Stein (1883) to Phalacroma. Oxyphysis also comprises but one species, *O. oxytoxoides* Kofoid (1926). Of the four new genera, Heteroschisma is based on two new species; Dinofurcula on two species, one of which is new, the other previously described and figured by Kofoid (1907a) under the generic name of Phalacroma; and Histiophysis on one species previously (Kofoid and Michener, 1911) referred to Dinophysis. Thecadinium comprises two species, viz., *T. petasatum* and *T. ebriolum*. Of these, the first was described and figured by Herdman (1922, p. 26) under the name of *Amphidinium kofoidi* var. *petasatum* and later (Herdman, 1923, p. 34) transferred to Phalacroma as *P. kofoidi*. The second species was introduced by Herdman (1924, p. 34) as *Phalacroma ebriola*.

The members of Thecadinium are, on the whole, the most primitive representatives of this family. Indeed, even their assignment to the tribe Dinophysoidae

must be considered as uncertain. It is true that they are characterized by a distinct theca (Lebour, 1925, pl. 11, fig. 1c, d), but the thickness of the pellicle in Gymnodinioidae is variable, and it appears probable that there are stages intermediate between unarmored forms with exceedingly thin and flexible pellicle and armored ones, *i.e.*, forms in which the pellicle has become more resistant and inelastic. If the theca is left out of consideration, the two species of Thecadinium are structurally much closer to Amphidinium than to any of the genera of Dinophysoidae. They evidently lack cingular lists and the left sulcal list is very narrow or absent. Furthermore, their longitudinal furrow appears to be deep, while in all the other members of this tribe it is flat or but slightly impressed. The close structural similarity between Amphidinium and Thecadinium indicates that the latter genus evolved directly from the former. It may be noted in this connection that the anterior position of the girdle is considered as secondary; in other words, in this respect these two genera are more advanced than some of the highly differentiated members of Phalacroma (*e.g.*, *P. limbatum*, Plate 3, fig. 5).

Next to Thecadinium, Pseudophalacroma and Oxyphysis appear to be the most primitive. This assumption is based on the following structural features: — (*1*) the longitudinal furrow continues anteriorly beyond the anterior cingular list (Stein, 1883, pl. 18, fig. 1; Kofoid, 1926, pl. 18, fig. 1); this peculiarity is found in a great number of the representatives of Gymnodinioidae, but in no other members of Dinophysoidae (Jörgensen, 1923, p. 4); (*2*) the epitheca is comparatively high and deep; (*3*) the cingular lists are very narrow and lack structural differentiation; (*4*) the sulcal lists are small, and the left of them lacks the three ribs and the posterior angularity characteristic of most of the members of the higher genera, viz., Phalacroma and Dinophysis. Pseudophalacroma appears to be very close to the evolutionary line that led to the development of Phalacroma and Dinophysis. Oxyphysis, on the other hand, forms an aberrant and in many respects highly differentiated branch that split off at a very early stage. It embodies many of the tendencies inherent in the peculiar genus Oxytoxum of the tribe Peridinioidae and furnishes one of the most striking examples of convergence known among the Protozoa (Kofoid, 1926).

The genus Heteroschisma is characterized especially by two structural features: — (*1*) the entire left sulcal list belongs to the right valve, its fission rib being located at the level of the posterior cingular list; (*2*) the left valve of the hypotheca has a triangular postcingular plate on the ventral side. The behavior of the left sulcal list in binary fission is not known in Thecadinium, Pseudophalacroma, and Oxyphysis. On the other hand, in the highly organized genera of

Dinophysidae, viz., Phalacroma, Dinophysis, and Histiophysis, the fission rib of this list is displaced posteriorly; in other words, the anterior portion of this list belongs to the left valve and the posterior to the right. Although there are no proofs in support of this assumption, Heteroschisma is considered primitive in this respect. Except in Heteroschisma, a triangular postcingular plate is not known to occur in any of the members of this tribe (with the possible exception of *Phalacroma fimbriatum*, Plate 2, fig. 1). For these reasons and because of the rounded outline of the body, the large size of the epitheca, and the simple structure of the left sulcal list, Heteroschisma is considered an independent evolutionary branch that split off at a very early stage. Furthermore, the entire organization of Heteroschisma, when compared with that of Thecadinium, Pseudophalacroma, Oxyphysis, and Phalacroma, indicates that this genus is much more closely related to Phalacroma and Pseudophalacroma than to Thecadinium and Oxyphysis.

Dinofurcula recalls Phalacroma in the great depth of the epitheca and in the moderate width, subhorizontal position, and ribbed structure of the cingular lists. On the other hand, it differs very strikingly from this genus in having the hypotheca bifurcate posteriorly. Another peculiarity of *Dinofurcula ultima* (Plate 5, fig. 4, 6) is the posterior displacement of the distal portion of the girdle, a feature not found in any other member of Dinophysoidae, but frequent in Gymnodinioidae and Peridinioidae. Dinofurcula, like Pseudophalacroma and Heteroschisma, represents an independent branch near the base of the evolutionary line that led to the differentiation of Phalacroma.

Of the three remaining genera of Dinophysidae, viz., Phalacroma, Dinophysis, and Histiophysis, all of which are structurally very closely related, the first is, on the whole, the most primitive. This is indicated by the following features:— (*1*) the body is frequently subrotund in lateral outline; (*2*) the epitheca is very large and the girdle is subhorizontal not only in some of the primitive, but also in some of the highly advanced species; (*3*) the cingular lists are relatively narrow. Phalacroma and Dinophysis embody several common tendencies, *e.g.*, the tendency to develop accessory sails and lists, and even their generic separation "seems . . . to be somewhat arbitrary" (Jörgensen, 1923, p. 5). It is very difficult to allocate generically not only several of their primitive but also some of their advanced members. Histiophysis, which is structurally more closely related to Dinophysis than to Phalacroma, shows certain similarities to Parahistioneis. For instance, its epitheca is very small, its anterior cingular list is unusually high, has a pronounced funnel shape, and simplified ribbing, its posterior cingular list

is reticulated instead of ribbed as in Phalacroma and Dinophysis, and it has phaeosomes in the girdle. The highly developed structure of the sulcal lists and the lack of a posterior main rib in the left sulcal list should also be taken into account when the systematic position of Histiophysis is under consideration.

In short, of the eight genera, six, viz., Pseudophalacroma, Heteroschisma, Dinofurcula, Phalacroma, Dinophysis, and Histiophysis, are structurally quite closely related, while the two remaining, viz., Thecadinium and Oxyphysis, occupy rather isolated positions. Thecadinium is still on the borderland to Gymnodinioidae, and Oxyphysis is a highly differentiated genus that branched off at a very early stage from the evolutionary line that led to the differentiation of the first six genera. Of Pseudophalacroma, Heteroschisma, and Dinofurcula, which also split off very early, the last is in some respects very aberrant, while the others are still, on the whole, quite primitive (see also Hensen, 1891, pl. 2).

Distribution: — The Dinophysidae are very widely distributed, exclusively marine, and all the genera are eupelagic, except Thecadinium which is found on sandy beaches. Most of the species occur exclusively, or almost so, in tropical, subtropical, and warm-temperate seas, but some of them are endogenetic in the Arctic and the Antarctic Oceans, where no representatives of the other families of this tribe are to be found. Most species appear to be rare, but some have been recorded as rather frequent. The optimum habitat is the lower levels of photosynthesis.

Key to the Genera

1. Cingular lists absent ..... *Thecadinium*, gen. nov.
1. Cingular lists present ..... 2.
2. Sulcus continues anteriorly beyond anterior cingular list ..... 3.
2. Sulcus does not continue anteriorly beyond anterior cingular list ..... 4.
3. Epitheca narrow, cone-shaped ..... *Oxyphysis* Kofoid.
3. Epitheca rounded, dome-shaped ..... *Pseudophalacroma* Jörgensen.
4. Body molariform in lateral outline ..... *Dinofurcula*, gen. nov.
4. Body not molariform in lateral outline ..... 5.
5. Entire left sulcal list belongs to right valve ..... *Heteroschisma*, gen. nov.
5. Entire left sulcal list does not belong to right valve ..... 6.
6. Posterior cingular list finely reticulated ..... *Histiophysis*, gen. nov.
6. Posterior cingular list not finely reticulated ..... *Dinophysis* Ehrenberg and *Phalacroma* Stein.

Heteroschisma, gen. nov.

Diagnosis: — Body subcircular to broadly subobovate in lateral outline. Epitheca large, but slightly narrower than hypotheca. Transverse furrow narrow, of subuniform width throughout, 0.43–0.70 the greatest height of epitheca. Posterior cingular list 0.36–0.46 the length of body from apex. Left hypotheca characterized by a triangular postcingular plate, occupying its ventroanterior corner; this plate is somewhat deeper than high, and its ventral height is 1.5–3.0 the width of the transverse furrow. Cingular lists subhorizontal and subequal, slightly wider to slightly narrower than transverse furrow; without structural differentiation except dorsally and ventrally, where they may have a few ribs. Right sulcal list about 0.33–0.45 as long as body, with a maximum width 0.66–0.75 the width of transverse furrow. The most important feature of the left sulcal list is that it belongs to the left valve in its entire extension; *i.e.*, that it crosses over from the left to the right valve at the level of the posterior cingular list. Other characteristics of this list are: — it is 0.53–0.67 as long as body, of subuniform width throughout the greater portion of its length, its average width being subequal to width of transverse furrow, forms a round to ear-shaped lobe posteriorly, and either lacks structural differentiation or has but a single rib near the posterior end.

Type.— *Heteroschisma inaequale*, sp. nov.

Distribution: — Heteroschisma has never been found outside the area investigated by the Expedition; and by the Expedition it was taken at five stations only. Two of these five stations (4665, 4671) are in the Peruvian Current; one (4699) is in the Easter Island Eddy; and two (4701, 4721) are in the South Equatorial Drift. All records refer to hauls from 300–0 fathoms except one (Station 4699) which refers to a specimen from the stomach of a Salpa taken in surface waters. The frequency is less than 1% at all the five record stations.

Heteroschisma aequale, sp. nov.

Plate 1, fig. 7, 8. Figure 1 : 1, 2

Diagnosis: — Body subcircular in lateral outline, deepest near the middle; in dorsoventral view obovate, widest at girdle. Posterior cingular list 0.45–0.46 the length of body from apex. Ventral margin of right sulcal list strongly sigmoid, concave anteriorly and convex posteriorly. Left sulcal list 0.53 the length of body, of subuniform width throughout the greater portion of its length; its

average width subequal to width of transverse furrow; postmargin of list protracted into narrow, ear-shaped lobe; without ribs or other structural differentiation. Theca finely and faintly reticulate. Length, 43.2–51.0 μ.

Eastern tropical and subtropical Pacific.

Description: — Body subcircular in lateral outline and deepest near the middle. The margins are confluent and subuniformly convex, and the epitheca, which is highest in the center, is about as broadly rounded as the posterior portion of the body. The longitudinal axis is about perpendicular to the girdle. The transverse furrow is flat or gently convex, and its width is about 0.43–0.44 the greatest height of the epitheca. The posterior cingular list is about 0.45–0.46 the length of the body from the apex. The ventral height of the triangular field is about 1.5 times the width of the transverse furrow. In dorsoventral view the body is obovate and widest at the girdle.

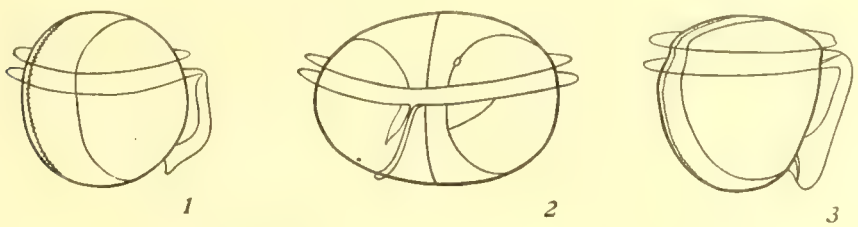

FIGURE 1.— 1, 2, *Heteroschisma aequale*, gen. et sp. nov. 1, right lateral view of type specimen, Station 4671 (300–0 fathoms); 2, ventral view, Station 4701 (300–0 fathoms); 3, *Heteroschisma inaequale*, gen. et sp. nov., right lateral view of type specimen, Station 4665 (300–0 fathoms). x 430.

The cingular lists are subhorizontal and subequal, about as wide as the transverse furrow or slightly narrower or wider, and, as far as the records go, without structure. The right sulcal list is 0.33–0.40 as long as the body; its ventral margin is strongly sigmoid, concave anteriorly, convex posteriorly; its maximum width is about 0.75 the width of the transverse furrow. The left sulcal list is about 0.53 the length of the body and of subuniform width throughout the greater portion of its length; its average width is subequal to the width of the transverse furrow; its greatest width is located in or somewhat behind the middle; its ventral margin is gently sigmoid, slightly concave or almost straight anteriorly, convex in the middle, and slightly concave posteriorly; its postmargin is protracted into a narrow, ear-shaped lobe at an angle of about 50°; there are no ribs or other structural differentiations. The thecal wall is finely and faintly reticulate; the meshes are of subuniform size and polygonal; pores were not seen.

Only megacytic stages were recorded. Two specimens had exceedingly wide intercalary zones.

Dimensions: — The dimensions of two specimens were: — Length of body, 43.2–51.0 μ (type, 51.0 μ). Total length of megacytic specimens, 54.0–55.4 μ.

Variations: — Judging by the few specimens available, this species appears to be quite constant in shape and structure and fairly variable in size.

Comparisons: — The description of the shape of the body is somewhat uncertain, since all the specimens examined are megacytic with very broad intercalary zones.

The simplicity of the structure of the thecal wall seems to indicate that *Heteroschisma aequale* is more primitive than *H. inaequale*.

Occurrence: — *Heteroschisma aequale* is recorded at four of the 127 stations. There are 0, 1, 0, 2, 1, and 0 stations on the six lines of the Expedition. Of these four stations, one (4671), the type locality, is in the Peruvian Current; one (4699) is in the Easter Island Eddy; and two (4701, 4721) are in the South Equatorial Drift. At one station (4699, Salpa stomach) the species was taken in surface waters. The remaining records refer to hauls from 300–0 fathoms.

The temperature range of these four stations at the surface is 66°–75°; the average was 72°. At Station 4699 the surface temperature was 75°.

The frequency in all the cases is less than 1%.

Heteroschisma inaequale, sp. nov.

Plate 1, fig. 1, 2. Figure 1 : 3

Diagnosis: — Body broadly subobovate in lateral outline, deepest at girdle. In dorsoventral view subbiconical, widest at girdle, side contours of epitheca and hypotheca almost straight or even slightly concave, except posteriorly where they are convex. Posterior cingular list 0.36 the length of body from apex. Ventral margin of right sulcal list almost straight anteriorly, gently convex posteriorly. Left sulcal list 0.67 the length of body, of subuniform width throughout; its average width subequal to width of transverse furrow; with rounded posteroventral lobe; with short posterior rib that ends at middle of postmargin. Wall of left hypotheca, except triangular field, has fine and rather faint reticulation; remaining portion of theca with well-developed and rather wide-meshed reticulation. Length, 51.0 μ.

Eastern tropical Pacific.

Description: — Body broadly subobovate in lateral outline and deepest at the girdle. The margins are subuniformly convex and confluent, and the epitheca, which is highest somewhat ventrally to the center, is somewhat more

broadly rounded than the posterior portion of the body. The longitudinal axis is about perpendicular to the girdle. The transverse furrow is slightly concave, and its width is about 0.70 the greatest height of the epitheca. The posterior cingular list is about 0.36 the length of the body from the apex. The ventral height of the triangular field is about three times the width of the transverse furrow. In dorsoventral view the body is subbiconical and widest at the girdle; in the type specimen (megacytic) the ratio between the length and width is 1.20:1; the side contours of the epitheca and hypotheca are almost straight or even slightly concave, except at the posterior end of the body where they are more or less convex.

The cingular lists are subhorizontal and subequal, about as wide as the transverse furrow or somewhat narrower, and without structural differentiation except dorsally and ventrally where a few (1–4) ribs are to be found. The right sulcal list is about 0.45 as long as the body, of subuniform width throughout the greater portion of its length, and with a maximum width about 0.66 the width of the transverse furrow; its ventral margin is almost straight anteriorly and gently convex posteriorly. The left sulcal list is about 0.67 as long as the body, of subuniform width throughout its entire length, and its average width is subequal to the width of the transverse furrow; it is characterized by a rounded posteroventral lobe and has no structural differentiation, with the exception of a short posterior rib that ends at the middle of the postmargin of the list and has a posterior inclination of about 80°.

The thecal wall of the right valve and of the epitheca, the transverse furrow, and the triangular field of the left valve have a well-developed reticulum of rather large polygonal meshes. The meshes of the epitheca and of the right hypotheca are subuniform in size; and about twenty meshes border the girdle posteriorly on the right valve. In the entire triangular field about sixteen meshes are to be found. The polygons of the transverse furrow are arranged in two rows; on each valve there are about sixteen or seventeen polygons in each row. Except in the triangular field the wall of the left hypotheca is characterized by a fine and rather faint reticulation resembling the one found in *Heteroschisma aequale*. Scattered pores are to be found.

The only specimen examined was megacytic.

Dimensions: — Length of body, 51.0 μ. Total length of megacytic specimen (including intercalary zone), 54.8 μ.

Comparisons: — The description of the shape of the body is somewhat uncertain since the only specimen examined is megacytic.

This species is easily distinguished from *Heteroschisma aequale* by the well-developed and comparatively wide-meshed reticulation of its theca.

Occurrence: — *Heteroschisma inaequale* is recorded at only one (4665) of the 127 stations, on the second line of the Expedition, in the Peruvian Current, from a depth of 300–0 fathoms, and at a surface temperature of 68°. The frequency is less than 1% (one specimen).

Phalacroma Stein

Phalacroma Stein, 1883, p. 23. Bütschli, 1885, p. 940, 1009. Delage & Hérouard, 1896, p. 385. Schütt, 1896, p. 26. Paulsen, 1908, p. 19. Lebour, 1925, p. 75.
Phalarocoma Daday, 1888, p. 99 (*lapsus pennae*).
Phalacromo Nathansohn, 1908, p. 601 (*typ. err.*).

Diagnosis: — Body usually subcircular, subellipsoidal, subobovate, subbiconical, subcuneate, or fig-shaped in lateral outline, distinctly longer than deep (length: depth, 0.86–1.84: 1), and more or less compressed bilaterally. Epitheca usually large (ratio between its depth and depth of hypotheca in most species somewhere between 0.8: 1 and 1.0: 1, sometimes as low as 0.54: 1), either high, even as high as hypotheca, or more or less flattened. Transverse furrow narrow, of subuniform width throughout, flat or but slightly convex or concave; its width, 0.07–0.12 the length of body. Cingular lists usually subhorizontal and subequal, slightly wider to slightly narrower than transverse furrow, with or without ribs; sometimes somewhat inclined anteriorly. Right sulcal list usually somewhat narrower than the left and ends somewhere between R_2 and R_3 of left. Left sulcal list usually subtrapeziform, somewhat wider posteriorly than anteriorly, with pronounced posteroventral angle, and with three main ribs, one (R_1) in front, and one (R_3) behind fission rib (R_2); R_2 somewhat behind girdle; sometimes this list extends to antapex, sometimes its length is only 0.33 the length of hypotheca; R_2 and R_3 at most 0.22 and 0.55 the greatest depth of body, respectively; margin may be rounded posteroventrally. Sometimes with accessory lists and sails.

Type. — *Phalacroma porodictyum* Stein.

Organology: — The *body* (*theca*) in Phalacroma is simple in structure, but diverse in shape. When seen laterally, it usually is somewhat asymmetrical, but symmetrical species also have been found (*e.g.*, *P. ovum*, Figure 11: 4). In dorsal or ventral view it appears always to be symmetrical. In many species the *longitudinal axis* (*a. l.*, Figure 29) has maintained its original position, *i.e.*, it is perpendicular to the girdle; frequently, however, it is more or less deflected posteroventrally. In the two species with the most pronounced posteroventral

deflection of this axis, viz., *P. porodictyum* and *P. expulsum*, an inclination of 1°–20° and 5°–15°, respectively, was found. The only species in which this axis has a slight (2°) posterodorsal inclination is *P. circumcinctum* (Plate 1, fig. 5).

When seen laterally, the *body* usually is distinctly longer than deep, only seldom is it deeper than long. In the most elongated species (*P. turbineum*, Plate 2, fig. 3) the ratio between the length and the depth is 1.84: 1; in the species with the relatively deepest body (*P. giganteum*, Figure 14: 1) the corresponding ratio is 0.86: 1; in most species it is between 1.1: 1 and 1.3: 1. Sometimes the body is deepest in or near the middle, but usually the greatest depth has shifted to the anterior third of the body. As a rule, the body is deepest at or just behind the girdle. No species with the greatest depth located anterior to the girdle has been found.

Usually the *body*, seen in lateral view, is circular or subcircular (*Phalacroma lativelatum*, Figure 3: 2, 3), ellipsoidal or subellipsoidal (*P. parvulum*, Figure 3: 4–6), obovate or subobovate (*P. circumsutum*, *P. doryphorum*, Figure 23). Of these shapes the last two are by far the most common. Although the circular shape is the most primitive, it is found not only in some of the primitive but also in some of the highly differentiated members of the genus (Plate 3, fig. 5). The following shapes of body, seen laterally, have also been found: — subcircular, with a slight (*P. lens*, Figure 4: 3) or striking (*P. contractum*, Figure 3: 1) constriction at the girdle; subcircular, with the anterior end subtruncate (*P. porosum*, Plate 1, fig. 6; *P. pulchrum*, Plate 3, fig. 6); rounded subbiconical (*P. praetextum*, Plate 4, fig. 6); subbiconical, with well-rounded apices (*P. fimbriatum*, Plate 4, fig. 4); biconical, top-shaped, narrowly to fairly broadly rounded anteriorly, subacute posteriorly (*P. reticulatum*, Plate 4, fig. 3; *P. turbineum*, Plate 2, fig. 3); irregularly obovate, with strikingly conical epitheca, or sublozenge-shaped (*P. apicatum*, Figure 10); sac-like, truncate anteriorly, with a dorsal shoulder-like constriction at the girdle (*P. expulsum*, Figure 20: 1); subobovate, with a broadly rounded angle at the posterior end of the left sulcal list (*P. acutum*, Schütt, 1895, pl. 3, fig. 17: 1); cuneate, with a very broadly rounded epitheca (*P. cuneus*, Figure 12); subcuneate, with the posterior margin strikingly sigmoid, convex anteriorly, concave posteriorly (*P. mitra*, Schütt, 1895, pl. 4, fig. 18: 1); subcuneate, very broadly rounded to nearly flat anteriorly, narrowly rounded to subacute but not mammilliform posteriorly, and with the ventral margin strikingly angular at the posterior main rib of the left sulcal list (*P. rapa*, Figure 16); subcuneate, broadly rounded anteriorly, constricted, mammilliform posteriorly, and with the ventral margin more or less angular at the posterior main rib of the left sulcal list

(*P. favus*, Plate 2, fig. 7); inverted fig-shaped (*P. hindmarchi*, Figure 18). A peculiarity worth mentioning is that species with ovoidal body have not been found as yet in Phalacroma, although this shape is fairly common in the closely related genus Dinophysis.

Generally the *body* is more or less compressed bilaterally; only a few species (*e.g.*, *Phalacroma globulus*, Schütt, 1895, pl. 2, fig. 12: 1; *P. fimbriatum*, Plate 4, fig. 4; *P. giganteum*, Plate 2, fig. 1) have the dorsoventral and transverse diameters subequal. It may also be mentioned that in the type specimen of *P. turbineum* (Plate 2, fig. 3; Plate 4, fig. 1) the transdiameter even exceeded the dorsoventral diameter, but this specimen possibly was megacytic (see p. 200). In the species with the most pronounced bilateral compression (*P. lens*, Figure 4: 1-3) the ratio between the length and the transdiameter is 2.38–2.66: 1, while the ratio between the length and the dorsoventral diameter is 1.05–1.11: 1. When seen in dorsoventral view, the body generally is obovate (*P. pulchrum*, Plate 3, fig. 1), ellipsoidal (*P. mucronatum*, Figure 22: 6), or lenticular (*P. limbatum*, Plate 3, fig. 3). In all the species with ellipsoidal or lenticular outline and in some of the species with obovate outline, the body is widest in or near the middle; in the remaining species with obovate outline the greatest width is located in the anterior third of the body, often near the girdle. The following shapes of body, seen dorsoventrally, have also been found: — subcircular (*P. globulus*, Schütt, 1895, pl. 2, fig. 12: 1, in which the body approaches the fundamental, spherical form); biconical, with more or less narrowly rounded apices (*P. apicatum*, Figure 10: 2; *P. circumcinctum*, Plate 1, fig. 4); biconical, with acute or subacute apices (*P. fimbriatum*, Plate 2, fig. 1; *P. reticulatum*, Plate 4, fig. 5); cuneate, broadly rounded anteriorly, narrowly rounded or subacute posteriorly; and with the side contours of the hypotheca straight, or evenly and gently convex or concave (*P. cuneolus*, Figure 22: 7), or more or less undulating (*P. expulsum*, Figure 20: 2, 5; *P. favus*, Figure 14: 2); inverted pyriform (*P. pyriforme*, Figure 4: 4); inverted fig-shaped (*P. hindmarchi*).

One of the most characteristic features of Phalacroma is the relatively large size of the *epitheca* (*epi.*, Figure 29). In lateral as well as in dorsoventral view, the epitheca usually is about as deep as or but slightly narrower than the hypotheca. In most species the ratio between the depth of the epitheca and that of the hypotheca is somewhere between 0.8: 1 and 1.0: 1; in the species with the relatively smallest epitheca (*P. expulsum*, Figure 20: 1, 3) the corresponding ratio is 0.60 (0.54–0.66): 1. Only in exceptional cases (*P. reticulatum*, Plate 4, fig. 3) is the epitheca slightly deeper than the hypotheca. In the ancestral forms of

this genus the epitheca and the hypotheca presumably were subequal in size, and this condition is still found in some of the recent species, *e.g.*, in *P. limbatum* (Plate 3, fig. 5), *P. praetextum* (Plate 4, fig. 6), and *P. circumcinctum* (Plate 1, fig. 5). However, in most of the recent forms the height of the epitheca has been more or less reduced without a corresponding reduction in depth. In some species this reduction in height has proceeded so far that the epitheca has the shape of a large and but slightly vaulted disk (*P. porosum*, Plate 1, fig. 6; *P. giganteum*, Plate 2, fig. 2; Plate 3, fig. 2). Only in a few of the known species (*P. expulsum*, Figure 20: 3) has this reduction in height been accompanied by a decided decrease in depth. *Phalacroma expulsum*, which in several respects is intermediate between Phalacroma and Dinophysis, is also the only representative of its genus in which the epitheca in lateral view is not at all or but slightly visible above the anterior cingular list. As a rule, the epitheca is highest in or near the center, and only in a few species has its greatest height shifted dorsally or ventrally (Figure 20).

In some species (*Phalacroma praetextum*, Plate 4, fig. 6; *P. limbatum*, Plate 3, fig. 5) the *transverse furrow* (*tr. f.*, Figure 29) has maintained its original equatorial position, but usually it is distinctly nearer to the anterior than to the posterior end of the body. Sometimes (*P. porosum*, Plate 1, fig. 6) it is even so close to the apex that its width exceeds the greatest height of the epitheca. Its distal portion is not displaced posteriorly, *i.e.*, it does not form a spiral about the body. It usually crosses the lateral faces of the body in an almost straight line, but in *P. porosum* (Plate 1, fig. 6) it forms a gentle, sigmoid curve. Its width is subject to but slight variations; in obovoidal and subcuneate species the width is about 0.07–0.09, in subrotund species about 0.11–0.12 the length of the body. Its floor usually is flat or but slightly concave or convex, and only in a few species (*P. contractum*, Figure 3: 1) is the concavity pronounced; this character appears to be fairly variable even within the species.

The *longitudinal furrow* usually is about half as long as the hypotheca but may be somewhat longer or shorter; *e.g.*, in *Phalacroma porosum* (Plate 1, fig. 3, 6) it is about 0.63 and in *P. turbineum* (Plate 4, fig. 1) about 0.26 the length of the hypotheca. Anteriorly it does not extend beyond the girdle, *i.e.*, into the epitheca. It is at most but slightly impressed.

The *lists of the furrows* are not excessively developed. They arise from low and narrow basal ridges (Plate 3, fig. 1, 6) and are hyaline and usually exceedingly delicate.

In almost all the species the *cingular lists* (*ant. cing. l.*, *post. cing. l.*, Figure

29) are subhorizontal, subequal, of subuniform width throughout, and about as wide as or slightly wider or narrower than the transverse furrow. The anterior appears usually to be closed, but may be open ventrally in some species (Plate 2, fig. 1; Plate 1, fig. 5, of *Phalacroma fimbriatum* and *P. circumcinctum*). The posterior is always open ventrally. Only in exceptional cases are these lists strikingly inclined anteriorly; in *P. expulsum* (Plate 5, fig. 1) and *P. pulchrum* (Plate 3, fig. 6), which have this anterior inclination better developed than any other members of the genus, these lists are inclined at about 30°–45° and 20°–40°, respectively. It should be remembered, however, that the pressure of the cover-glass is likely to change the inclination of these lists. In the species with the widest cingular lists (*P. protuberans*, Figure 20:8), these are about 1.7–2.3 times wider than the transverse furrow; in *P. contractum* (Figure 3:1) and *P. lenticula* (Figure 3:7), which form the opposite extreme, they are only about half as wide as the transverse furrow. In the most primitive as well as in some of the highly developed species (*P. circumcinctum*, Plate 1, fig. 5; *P. pulchrum*, Plate 3, fig. 6), the cingular lists appear to lack structural differentiation, except for one or two ribs dorsally and ventrally on each valve near the sagittal suture. In the remaining species both these lists are ribbed. The ribs usually are rather strong, straight, simple, and nearly equidistant; but they may be fairly irregular (*P. striatum*, Plate 2, fig. 5), or they may even anastomose into a reticulum (*P. cuneus*, Schütt, 1895, pl. 3, fig. 14:2; *P. striatum*, Jörgensen, 1923, fig. 12). The number of ribs in the anterior list is either subequal to or somewhat larger than that in the posterior. In some species (*P. turbineum*, Plate 2, fig. 3) these lists have only a few ribs, but in others the number is fairly large; for instance, in *P. giganteum* (Plate 2, fig. 2), each of these lists has, on each valve, as many as seventy-five ribs.

The *sulcal lists*, which form a direct continuation of the posterior cingular list, run about parallel to each other on either side of the longitudinal furrow. While the entire right sulcal list belongs to the right valve, the anterior portion of the left list belongs to the left valve and the posterior portion to the right.

The *right sulcal list* (*r. sulc. l.*, Figure 29) is fairly variable in size and shape even within the species. It always is smaller than the left. In some species (*Phalacroma porosum*, Plate 1, fig. 6; *P. favus*, Plate 2, fig. 7) it extends to or slightly beyond the posterior main rib of the left sulcal list; in others (*P. striatum*, Plate 2, fig. 8) it ends at a point somewhere between the fission rib and the posterior main rib of the last-mentioned list; only exceptionally (*P. expulsum*, Plate 5, fig. 1) does it end at or even in front of the fission rib. Usually, it either (*P. limbatum*, Plate 3, fig. 5) is subtriangular to rounded triangular, about as wide as

the transverse furrow anteriorly, and decreasing gradually in width posteriorly; or (*P. favus*, Plate 2, fig. 7) of subuniform width throughout the greater portion of its length, fairly strongly rounded posteriorly, and about as wide as the transverse furrow anteriorly. The following shapes have also been found: — crescent shape, wider in the middle than anteriorly and posteriorly (*P. porosum*, Plate 1, fig. 6); the anterior half to two thirds of the free margin is more or less concave and forms a distinct angle with the posterior portion of the margin which is either straight (*P. fimbriatum*, Plate 4, fig. 4) or more or less convex (*P. striatum*, Plate 2, fig. 8); the free margin is sigmoid, concave anteriorly and convex posteriorly (*P. giganteum*, Plate 2, fig. 2). Usually this list lacks structural differentiation, but sometimes it has a marginal rib (*P. striatum*, Plate 2, fig. 8; *P. argus*, Figure 8: 1), a T-shaped rib (*P. turbineum*, Plate 4, fig. 1), or a more or less developed reticulation (*P. striatum*, Plate 2, fig. 8; *P. circumcinctum*, Plate 1, fig. 5); the reticulation is always first developed along the base of the list. The ventral margin is always free.

The *left sulcal list* (*l. sulc. l.*, Figure 29) is also strikingly variable in size and shape. It usually is about half as long as the hypotheca or slightly longer, but sometimes (*Phalacroma turbineum*, Plate 2, fig. 3) it is only about 0.33–0.39 as long as the hypotheca, or (*P. striatum*, Plate 2, fig. 8) it may extend as far as to the antapex. In most species it is subtrapeziform, somewhat wider posteriorly than anteriorly, with a pronounced posteroventral angle, and with the ventral and posterior margins straight, or gently concave, convex, or sigmoid; in some of the species of this category (*P. porosum*, Plate 1, fig. 6) the ventral margin may be very broadly angular near the middle. The posteroventral angle frequently is between 80° and 95°, but sometimes this portion of the list is more or less acuminate (*P. bipartitum*, Figure 21: 2; *P. circumsutum*, Figure 23: 6), or it shows intermediate stages between an angular and a rounded outline. In some species (*P. apicatum*, Figure 10: 4) the entire free margin of the list is almost evenly rounded, in others (*P. argus*, Figure 8: 1) it is more or less sigmoid, concave anteriorly and convex posteriorly. It also should be mentioned that in one species, viz., *P. praetextum* (Plate 4, fig. 6), this list is subtriangular, decreasing gradually in width posteriorly. In nearly all the species this list has three well-developed cross-ribs, which in the present paper have been named the anterior main rib, the fission rib, and the posterior main rib. The anterior main rib (*ant. m. r.*, Figure 29) is located anteriorly, at the junction of this list and the posterior cingular list; the fission rib (*f. r.*, Figure 29), at the place where the list is divided in binary fission, *i.e.*, at the sagittal suture and usually somewhat in front of the

middle of the list; the posterior main rib (*post. m. r.*, Figure 29), near the posterior end of the list. Usually the anterior main rib and the fission rib are subequal, or either of them is slightly longer than the other; and the posterior main rib, as a rule, is between 1.5 and 2.5 times longer than the fission rib. The relative length of the posterior main rib is more variable than that of either of the two anterior ribs. Sometimes (*P. doryphorum*, Figure 23; *P. ovum*, Figure 11) this rib is as much as 2.8–3.5 times longer than the fission rib, sometimes (*P. giganteum*, Figure 14:1; *P. argus*, Figure 8:1, 2) it is more or less reduced in length or even absent (*P. expulsum*, Plate 5, fig. 1). When the posterior main rib is well developed, the posteroventral margin of the list is angular, and the rib ends at or near the vertex of the angle; when the length of this rib is more or less reduced or when this rib is absent, the posteroventral margin of the list is rounded (*P. giganteum*, Figure 14:1) or almost straight (*P. praetextum*, Plate 4, fig. 6). When compared to the depth of the body, the maximum length of the fission rib and the posterior main rib is about 0.22:1 and 0.55:1 (*P. circumsutum*, Figure 23:6). The minimum length of the fission rib, expressed in the same manner, is about 0.07:1 (*P. argus*, Figure 8:1). The main ribs always are unbranched, straight or but slightly curved, and usually of moderate strength, and tapering distally. The fission rib frequently (always?) is double, *i.e.*, there is one rib on either side of the suture (*P. porosum*, Plate 1, fig. 3, 6); and it may be T-shaped, in which case it is divided distally in two branches, which form a marginal rib along the anterior half of the list (*P. circumcinctum*, Plate 1, fig. 5). The posterior main rib, which sometimes is more or less club-shaped distally (*P. doryphorum*, Figure 23:1; *P. hindmarchi*, Figure 18:3), generally has a posterior inclination of about 45° and may be directed straight back (*P. striatum*, Plate 2, fig. 8). In all the primitive and in many of the more or less highly differentiated species this list appears to lack structural differentiation except for the main ribs; in others it may have a number of short, secondary ribs (*P. favus*, Plate 2, fig. 7), or a more or less developed reticulation (*P. striatum*, Plate 2, fig. 8; *P. hindmarchi*, Figure 18:3). It also should be mentioned that in *P. limbatum* (Plate 3, fig. 5) and *P. pulchrum* (Jörgensen, 1923, fig. 18) this list has a fine rib just behind the posterior main rib that extends to the margin of the list. The left sulcal list of *P. turbineum* (Plate 2, fig. 3) is of an exceptional type; its length is, as previously mentioned, only 0.38–0.39 the length of the hypotheca; and its greatest width is 0.12–0.13 the greatest depth of the body; its free margin is gently and evenly convex; it has a weak cross-rib somewhat in front of its middle and a submarginal rib along its entire length; with the exception of these two ribs, this list appears to lack struc-

tural differentiation. With regard to this list in *P. fimbriatum*, see p. 192. In most species this list ends a very short distance behind the posterior rib, but in some (*P. favus*, Figure 14:4, 5) it is more or less decurrent. The last condition is, in a sense, an initial step in the development of a parasagittal list (see *P. cuneolus*, Figure 22:1–3).

The primitive species have no lists except the cingular and sulcal lists. On the other hand, in many of the more or less highly evolved forms, *accessory lists* are developed. As an example of a highly differentiated and, if we may say so, almost schematical system of accessory lists, these lists in *Phalacroma limbatum* (Plate 3, fig. 3, 5) may first be described. In this species two lists, the *parasagittal lists* (*par. l.*, Figure 29), encircle the body, one on either side of the sagittal suture; however, in the transverse furrow parasagittal lists never are developed, and the left list ends at or near the posterior end of the longitudinal furrow. The left parasagittal list is of subuniform width throughout its entire length, has a maximum width which is subequal to or somewhat less than the width of the transverse furrow, and is furnished with a moderate number of simple, free or anastomosing, incomplete riblets. The right parasagittal list, which directly continues the left sulcal list, resembles the left, but forms on the antapex an acute, wedge-shaped process, the *posterior sail* (*post. s.*, Figure 29), directed posteriorly. When fully developed, the posterior sail is 0.15–0.27 the greatest depth of the body in length and has a central rib, the proximal half of which might form a more or less complex reticulum; the angle at its tip is 35°–50°. Of this fundamental system there are a great number of variants, the most important of which will now be described. In *P. fimbriatum* (Plate 4, fig. 4; Plate 2, fig. 1) the two parasagittal lists also encircle the whole body. On the epitheca both lists are of about the same width and structure; from the apex, where their width about equals 0.09 the greatest depth of the body, they slightly decrease in width toward the girdle; each of them has about twenty almost equidistant ribs, a few of which are branched. On the hypotheca the left list is very narrow, at most about half as wide as the transverse furrow. The right is much wider than the left, lacks a posterior sail, and merges so completely in the left sulcal list that the boundary between these two lists cannot be established with certainty. From the posterior main rib of the left sulcal list to the antapex, the right parasagittal list is of nearly subuniform width, about 0.14–0.20 the greatest depth of the body; anterodorsally to the antapex this list gradually becomes narrower, and its average width on the dorsal side of the hypotheca is only about 0.07 the greatest depth of the body. The right parasagittal list of the hypotheca has about

twenty-six fairly strong and almost equidistant ribs, most of which are simple and almost straight, a few irregular or irregular and branched. The structure of the left list is unknown. As a last example of a species with the two parasagittal lists extending around the whole body, *P. turbineum* (Plate 2, fig. 3; Plate 4, fig. 1, 2) may be mentioned. In this species the right parasagittal list forms a direct continuation of the left sulcal list and lacks a posterior sail. On the average both the parasagittal lists are about twice as wide on the posterior half of the body as on the anterior half, and their maximum width is about 0.08–0.09 the greatest depth of the body. Each of them has a moderate number of short, simple ribs, approximately six on the epitheca and eighteen on the hypotheca. In most species the parasagittal lists are less developed than in the examples mentioned above. Generally speaking, the phylogenetic development of these lists appears to have proceeded from the posterior end of the body to the anterior, and the development of the right list seems to have preceded that of the left. In order to illustrate this statement, a few examples will be given. *P. pulchrum* (Plate 3, fig. 6) has two parasagittal lists on the hypotheca, but none on the epitheca. The left one of these two lists extends, on the dorsal side of the body, from the posterior cingular list to the antapex; it is very narrow, its maximum width being less than the width of the transverse furrow; and it is furnished with a few cross-ribs; in some specimens it may even be absent. The right parasagittal list forms a direct continuation of the left sulcal list and either extends to the posterior cingular list or is absent from the dorsal side of the hypotheca; dorsally it is of about the same type as the left list; posteriorly and posteroventrally of about the same type as the corresponding list in *P. limbatum*, only, as a rule, somewhat wider and with a slightly different structural differentiation. In *P. bipartitum* (Figure 21:2) only the right parasagittal list is present; it is restricted to the posterior half of the hypotheca, but still is connected with the left sulcal list. A peculiar feature of this species is that there are two posterior sails of about the same type as the corresponding structures in *P. limbatum*, one on each side of the antapex. In a fairly great number of species (*P. doryphorum*, Figure 23) only the posterior sail of the right parasagittal list is developed. This sail is subtriangular or wedge-shaped and is either situated on the antapex and directed posteriorly or slightly displaced ventrally and inclined posteroventrally. When fully developed, its length usually is about 0.20 0.40 the greatest depth of the body, and it is about as wide at the base as it is long or more or less decidedly narrower (*P. pugiunculus*, Jörgensen, 1923, fig. 19). Sometimes this sail has a central rib, sometimes it is more or less reticulated, especially in its central

portion; sometimes both the central rib and the reticulation are developed; sometimes no structure can be distinguished. Only in a few of these species (*P. circumsutum*, Figure 23: 6; *P. cuneolus*, Figure 22: 1, 2) a connection is developed between the posterior sail and the left sulcal list.

The *flagellar pore* (*f. p.*, Figure 29) is a fairly large opening, located in the longitudinal furrow, *i.e.*, on the right valve, and just behind or about a girdle width behind the posterior cingular list. Its shape usually is subcircular or slightly elongated, in exceptional cases subtriangular (*Phalacroma porosum*, Plate 1, fig. 3) or slightly irregular. It is variable in size, but its greatest diameter appears never to exceed the width of the transverse furrow. Other pores to be mentioned in this connection are as follows: — in *P. praetextum* (Plate 4, fig. 7) there is a fairly small pore on the ventral side of the left valve, near the sagittal suture, and just behind the anterior cingular list. In *P. pulchrum*, *P. giganteum*, and *P. striatum* (Plate 3, fig. 1, 2; Plate 2, fig. 5) there are one to three fairly small pores on the ventral side of the left valve, near the sagittal suture, and just in front of the anterior cingular list. Although pores of the last-mentioned kind have been observed only in a comparatively small number of species, it is not impossible that they are characteristic of the genus as a whole. Their significance is not apparent.

Both *flagella* arise in the flagellar pore and are well developed. The transverse flagellum (Schütt, 1895, pl. 2, fig. 11: 2) lies in the girdle and encircles the body from the left around to the right. The longitudinal flagellum (Schütt, 1895, pl. 2, fig. 13: 6), which is about as long as the body or slightly longer or shorter, passes posteriorly between the sulcal lists.

The structure of the *thecal wall* is very different in the various species and affords important systematic characteristics. In most species there is a varying number of pores and poroids (Schütt, 1895, p. 21, 22) more or less uniformly scattered all over the theca. Sometimes (*Phalacroma fimbriatum*, Plate 4, fig. 4) these structures are numerous, sometimes (*P. turbineum*, Plate 4, fig. 1, 2) they are few, sometimes (*P. praetextum*, Plate 4, fig. 6, 7) they appear even to be absent. In *P. turbineum* they seem to be restricted to the transverse furrow and only about fifteen in number. In some species the theca appears to lack structural differentiation except for the pores and poroids, but usually it is characterized either by areolation or by reticulation. The areoles, which are small, rounded pits and usually more or less closely set (*P. circumcinctum*, Plate 1, fig. 5), resemble the poroids, with which they are connected by transitional structures (Schütt, 1895, p. 22). The meshes of the reticulation usually are

fairly uniform in size within the species, but show a wide range of variation within the genus as a whole. In *P. striatum* (Plate 2, fig. 8), which is characterized by meshes of moderate size, twenty-five to thirty-five meshes on each valve border the posterior margin of the transverse furrow; in *P. favus* (Plate 2, fig. 7) the corresponding value is twenty to twenty-five; in *P. praetextum* (Plate 4, fig. 6), about fifteen; in *P. fimbriatum* (Plate 4, fig. 4), about ten; and in *P. turbineum* (Plate 2, fig. 3), five. In the last species the meshes are relatively larger than in any other known species. The ridges between the meshes sometimes are so fine that the reticulation hardly can be distinguished, sometimes (*P. fimbriatum*, Plate 4, fig. 4) they are rather heavy. It should be remembered in this connection that the degree of structural differentiation varies with age. The new valve of a recently divided specimen is thin and almost without structure; in old specimens the thecal wall is more or less heavy and its structural peculiarities are well developed. In most species the areolation or reticulation covers the whole thecal surface, in others (*P. limbatum*, Plate 3, fig. 4, 5) the regions nearest to the sagittal suture remain more or less undifferentiated. In *P. cuneus* (Figure 12) and related species a spine-like process projects into the cytoplasm from a point near the middle of the right sulcal list. *P. praetextum* (Plate 4, fig. 6, 7) is especially characterized by a dumbbell-shaped area, located on the ventral side of the hypotheca, just to the left of the sulcus, and extending on both sides of the sagittal suture from the posterior cingular list to the antapex. This area, which has a maximum width of about 0.33 the dorsoventral diameter of the body, is characterized by a structure quite different from that of the remaining portion of the theca. It has a faint reticulum of very small meshes, and in the middle of each or at any rate of most of these meshes there is an exceedingly fine pore. In other words, this area has the structure of a cribriform plate. Presumably it is a permanent structure; *i.e.*, it appears not to correspond to the intercalary zones of megacytic specimens (see p. 189).

With regard to the shape and structure of the *intercalary zones* of the megacytic specimens, see p. 51.

The *sagittal suture* of the two valves appears always to be finely serrated (Plate 2, fig. 1, 4). The three plates, epithecal, cingular, and hypothecal, of each valve very seldom are found separated. In one specimen of *Phalacroma giganteum*, the epithecal was detached from the cingular by means of the pressure of the cover-glass.

The *protoplasmic contents* are coarsely alveolar and hyaline, or may be of a pale rose or brownish color. The *nucleus*, which usually is located on the dorsal

side of the hypotheca (Schütt, 1895, pl. 2, fig. 11: 1, 2; 13: 3, 6), is rather large, ellipsoidal, ovoidal, or spherical, and has a moniliform chromatin reticulum. Probably in all species there are one or two, usually two, large *pusules*, which open by short and slender canals into the flagellar pore (Schütt, 1895, pl. 2, fig. 11: 2). In many species *chromatophores* are absent; when present, these structures appear usually to be small, rod-shaped, and yellowish (Schütt, 1895, p. 64, pl. 3, fig. 16: 4; 17: 2). A characteristic feature of many species is the presence of rod-like or thread-like *rhabdosomes*, which in most cases are arranged radially (Schütt, 1895, pl. 2, fig. 11: 2; 13: 3). *Metaplasmic inclusions* of different kinds, *e.g.*, globules of fats and oils, also have been found. See also Schütt (1895) and Bütschli (1885). The cell sometimes (*Phalacroma pulchella*, Lebour, 1922, p. 817) is "full of large refractive bodies."

The *length of the body* is very variable within the species as well as within the genus. For the genus as a whole the range of variation in length thus far established is from 21 μ (*Phalacroma pulchellum*) to 148 μ (*P. giganteum*).

Reproduction: — The only mode of reproduction known in Phalacroma is binary fission of the free-swimming individuals. The line of fission or, in other words, the sagittal suture lies in the sagittal plane except in the region of the sulcus. Probably in most species the whole flagellar pore and the entire longitudinal furrow belong to the right valve (Schütt, 1895, pl. 3, fig. 16: 3). It is possible, however, that sometimes the portion of the longitudinal furrow that is in front of this pore belongs to the left valve, as in the specimen of *Dinophysis jörgenseni* (Plate 5, fig. 3). Since in all species the flagellar pore is located near the junction of the sulcus and the cingulum, by far the larger portion of the longitudinal furrow always belongs to the right valve. The whole right sulcal list belongs to the right valve. The left sulcal list is divided at the fission rib, which probably is always double (Plate 1, fig. 6) although, when seen in lateral view, it usually appears to be single. The portion of this list which is in front of the fission rib belongs to the left valve, the portion behind this rib to the right valve. The right parasagittal list and the posterior sail or sails belong exclusively to the right valve, the left parasagittal list exclusively to the left valve.

Neither the cingular and sulcal lists nor the parasagittal lists and the posterior sails are resorbed in binary fission (Schütt, 1895, pl. 2, fig. 10). Whether or not the flagella (of the right valve) are shed is not known. The flagella of the left valve are fairly well developed before the detachment of the two schizonts (Schütt, 1895, pl. 3, fig. 16: 4), and so the dividing specimens probably continue their active swimming during the fission processes.

The growth of the cingular and sulcal lists and the development of the thecal wall in the new halves of the two schizonts probably take place fairly rapidly. This is indicated by the fact that one rather seldom finds specimens in which these structures are not completely developed. Furthermore, judging by Schütt's figure (1895, pl. 3, fig. 16: 3), the cingular lists are fairly well developed even before the schizonts separate; see, however, Meunier (1910, p. 59). On the other hand, the development of the parasagittal lists and of the posterior sails, which presumably are phylogenetically rather young structures, appears to be rather slow. In any case, the posterior sails of the specimens of *Phalacroma doryphorum*, etc., examined were found to be very variable in size, and in species with parasagittal lists many specimens lacked these structures or had them very incompletely developed. For a better understanding of the value of the last-mentioned structures in the differentiation of species, their post-fission development should be submitted to a careful study.

Double specimens or groups of specimens resulting from fission or repeated fissions, such as have been found in *Dinophysis caudata* and *D. miles*, are unknown in Phalacroma.

A phenomenon that possibly may be characteristic of the genus as a whole (Pavillard, 1916, p. 47) is the pronounced increase in size that precedes binary fission and that is accompanied by the development of the so-called intercalary bands (Stein, 1883, p. 23) along the sagittal margins of the two valves. Specimens with intercalary zones or, according to Pavillard's (1915a) terminology, megacytic specimens, have been found in twenty-one of the forty-seven presumably valid species of this genus, viz., *Phalacroma acutum* (by Pavillard, 1916), *P. argus* (by Jörgensen, 1923), *P. cuneolus* (by us), *P. cuneus* (by Pavillard, 1915a, 1916; and by us), *P. doryphorum* (by Pavillard, 1915a, 1916; Jörgensen, 1913; and by us), *P. favus* (by Jörgensen, 1923), *P. fimbriatum* (by us), *P. giganteum* (by us), *P. globulus* (by Schütt, 1895), *P. hindmarchi* (by us), *P. mitra* (by Pavillard, 1915a, 1916), *P. mucronatum* (by us), *P. ovum* (by us), *P. paulseni* (by Paulsen, 1911b), *P. porodictyum* (by Stein, 1883; Schütt, 1895), *P. porosum* (by us), *P. pulchellum* (by Lebour, 1922), *P. rapa* (by Stein, 1883; Pavillard, 1915a, 1916), *P. rotundatum* (by Meunier, 1910), *P. rudgei* (by Murray and Whitting, 1899), and *P. vastum* (by Schütt, 1895); see also p. 198.

The intercalary zone, which appears to be of varying width in the different species, is relatively wide on the dorsal side of the body and decreases gradually in width toward the ventral side; in the region of the sulcus it appears usually to be very narrow or not developed at all. Sometimes, as in *Phalacroma mitra*

(Pavillard, 1916, p. 49), it has about the same structure as the thecal valves. In most cases, however, its structure is strikingly faint. In some species, *e.g.*, in *P. doryphorum* (Pavillard, 1916, fig. 12), this zone under low magnification appears to have closely set fine transverse striation; under higher magnifications each of the striae proves to be a row of closely set minute areoles.

The intercalary bands are transitory structures. When the new valve is formed in binary fission its sagittal margin is attached to the premegacytic sagittal margin of the old valve, and the intercalary band soon disappears; presumably it is resorbed. For further discussion of this interesting phenomenon, see Pavillard (1915a, 1916), who was the first to submit it to a careful study.

Finally, it may be mentioned that Bergh (1881b, p. 226) recorded a specimen of *Dinophysis laevis* [= *Phalacroma rotundatum* (Clap. and Lach.) var. *laevis* (Claparède and Lachmann) Jörgensen] in a resting condition ("im Ruhezustand, zu einer Kugel innerhalb der Schale zusammengezogen"). The significance of this observation must be regarded as uncertain (see Bütschli, 1885, p. 1020), since encystment has not been investigated or definitely known to occur in the Dinophysoidae.

Distribution: — The rather extensive data on the distribution of Phalacroma published at the present writing show that this genus is marine, almost exclusively eupelagic, of general oceanic distribution, but that the great majority of its species are limited to waters of tropical, subtropical, or warm-temperate nature or origin. The great difficulties implied in the determination of several of the species of this genus, the broad concept of species held by many of the investigators in this field, and the fact that but relatively few of the data are accompanied by figures or descriptions by means of which the determinations of species may be checked (see p. 58) make the general distribution of many of the species rather uncertain. The distribution of the genus as a whole, on the other hand, may be regarded as fairly well established.

Phalacroma rotundatum, *P. ovatum*, *P. paulseni*, *P. rotundatum* var. *laevis*, *P. minutum*, and *P. rudgei* are known to occur in the cold waters of the far north. *Phalacroma rotundatum* has been found along the whole coast of Norway, off Greenland, and in the Arctic Ocean; *P. ovatum*, on the west coast of Norway and off Greenland; *P. paulseni*, off Greenland; *P. rotundatum* var. *laevis*, on the west coast of Norway; and *P. minutum* and *P. rudgei*, in the Atlantic Ocean between lat. 58° N. and lat. 60° N. Of these species, *P. rotundatum*, *P. ovatum*, *P. paulseni*, and *P. rotundatum* var. *laevis* are endogenetic in the northern waters, while *P. minutum* and *P. rudgei* are probably southern forms, occasionally carried to the

far north by the Gulf Stream. In the Antarctic Ocean *P. rotundatum* var. *laevis* has been found by Karsten (1905) as far to the south as lat. 63° S. It is a striking fact that all these species are small, rotund, and simply organized. The more or less luxuriant species appear to be restricted to warm-water regions (Schütt, 1893, p. 269). The only species of this genus known to be endogenetic in brackish waters is *P. rotundatum*, which has been recorded repeatedly from the less saline regions of the Baltic Sea.

Phalacroma is found in surface waters, but its optimum habitat seems to be the deeper levels of photosynthesis (Karsten, 1907, p. 442, 444). Some species, possibly saprozoic, have been found almost if not quite below the photic zone. It should be remembered, however, that the vertical distribution of this genus is very incompletely known, since but few records based on catches made with closing nets are available. The following from Karsten's (1905, 1906, 1907) reports on the phytoplankton of the Valdivia Expedition are the only published records. *Phalacroma rotundatum* var. *laevis* was found at Station 132, 400–300 m.; Station 151, 200–100 m.; *P. operculatum* at Station 170, 200–100 m.; Station 229, 200–20 m.; and Station 268, 63–46 m. *Phalacroma doryphorum* was taken at the following stations: — Station 227, 1000–800 m.; Station 228, 420–350 m.; Station 229, 1600–1400 m.; Station 239, 120–105 m.; Station 268, 105–88 m. and 63–46 m. All the specimens recorded were reported as "living." The specimens of *P. doryphorum* taken at great depths were found to be without chromatophores.

Although many of the species are widely distributed, none of them has been found to be abundant or even common. Indeed, most of these species appear to be rare, some even very rare.

Representatives of Phalacroma were found at 100 (78.7%) out of the 127 stations of the Expedition from which dinoflagellates were recorded. These 100 stations are distributed over the whole area covered by the Expedition as shown in the following table and Plate **24**: —

	Number of Stations and Occurrences	Number and % of Occurrences		
				%
California Current	4571, 4574, 4580, 4583	*4*	*4*	100
Mexican Current	4587, 4588, 4590, 4592, 4594, 4596, 4598, 4600, 4604, 4605, 4607, 4545, 4546	*13*	*13*	100
Panamic Area	4609, 4611, 4613, 4615, 4617, 4619, 4624, 4631, 4634, 4635, 4637, 4638, 4640, 4644	*14*	*17*	82.3
Peruvian Current	4646, 4647, 4648, 4650, 4651, 4652, 4655, 4657, 4659, 4660, 4661, 4662, 4663, 4664, 4665, 4666, 4667, 4668, 4669, 4670, 4671, 4673, 4675, 4676, 4678	*25*	*27*	92.6
Easter Island Eddy	4689, 4691, 4692, 4695, 4697, 4699	*6*	*10*	60
Galapagos Eddy	4713, 4715	*2*	*4*	50

	Number of Stations and Occurrences	Number and % of Occurrences		%
South Equatorial Drift	4679, 4680, 4681, 4683, 4685, 4687, 4701, 4705, 4706, 4707, 4709, 4711, 4717, 4719, 4720, 4721, 4722, 4724, 4725, 4728, 4730, 4731, 4732, 4733, 4734, 4736, 4737, 4739, 4740, 4741.	*30*	*45*	66.6
South Equatorial Current	4540, 4742, 4743	*3*	*3*	100
Equatorial Counter Current	4541, 4542	*2*	*2*	100
North Equatorial Current	4543	*1*	*2*	50

At sixty-seven of these 100 stations Phalacroma was taken in vertical hauls and at forty-five in surface hauls. Most of the records from vertical hauls are from 300–0 fathoms, some are from 800, 400, 150, 100–0 fathoms. Vertical hauls were made at sixty-eight out of the 127 stations. The genus thus was found at not less than 98.5% of the stations at which vertical hauls were made; it was absent from one station only, 4574 in the California Current, at which it was found in a surface haul.

Surface catches and Salpa stomachs of specimens taken in surface waters (eighty-one surface catches and twenty-four samples of Salpa stomachs) were examined from eighty-two stations. The genus, as previously mentioned, was taken in surface hauls at forty-five stations, *i.e.*, at 54.9% of all the surface stations. Taking into consideration the surface stations only, these forty-five record stations are distributed in the following manner:—

	Number of Stations and Occurrences	Number and % of Occurrences		%
California Current	4574, 4583	*2*	*4*	50
Mexican Current	4588, 4590, 4592, 4596, 4600, 4604, 4607, 4545, 4546	*9*	*9*	100
Panamic Area	4611, 4615, 4617, 4619, 4624, 4631, 4635, 4640, 4644	*9*	*13*	69.2
Peruvian Current	4648, 4650, 4657, 4660, 4661, 4664, 4666, 4669, 4675, 4676, 4678	*11*	*20*	55
Easter Island Eddy	4692	*1*	*5*	20
Galapagos Eddy	——	*0*	*2*	0
South Equatorial Drift	4680, 4706, 4709, 4720, 4725, 4731, 4733, 4741	*8*	*23*	34.7
South Equatorial Current	4743, 4540	*2*	*2*	100
Equatorial Counter Current	4541, 4542	*2*	*2*	100
North Equatorial Current	4543	*1*	*2*	50

On account of the prevalence of Phalacroma in deeper waters, the distribution and the frequency of the record stations at which *vertical* hauls were made should be used as an indicator of the horizontal distribution of this genus in the area investigated by the Expedition. These records show that the genus is almost evenly distributed throughout this area; indeed, it was found at not less than 98.5% of the stations at which vertical hauls were made. Furthermore, the even distribution of this genus is also evident when the distribution and frequency of the records of species are considered (Plate 24). The only region in

which Phalacroma was found to be represented rather sparingly was the California Current; north of Point San Lucas there were only four records of species, viz., three records of *P. parvulum* and one record of *P. rapa*. This scarcity possibly may be due to the fact that the California Current comes from the north, in other words, from a region where this genus is less abundant than within the tropics and subtropics. Of the eight most frequent species, *P. argus*, *P. cuneus*, *P. doryphorum*, *P. porodictyum*, and *P. rapa* (Figure 9, 13, 24, 7, 17) were found to be almost evenly distributed throughout the area investigated; *P. reticulatum* (Figure 26) was not found north of the equator; *P. striatum* (Figure 15) was not found in the California, Mexican, and Peruvian Currents; and *P. hindmarchi* (Figure 19) was restricted to the southwestern portion of this area, in other words, it had the same peculiar distribution as *Amphisolenia schauinslandi* (Figure 51) and *A. thrinax* (Figure 59).

The surface record-stations of Phalacroma are very unevenly distributed. While this genus was found at twenty-nine (69.0%) out of the forty-two surface stations in the Mexican Current, the Panamic Area, and the Peruvian Current, it did not occur at more than nine (30.0%) out of the thirty surface stations in the South Equatorial Drift, the Easter Island Eddy, and the Galapagos Eddy. The causes of this uneven distribution may lie in the greater influence of vertical circulation in the regions nearer to the western shores of the continents. It should also be mentioned that there is no surface species of this genus prevalent in the coastal regions as in the case of Dinophysis (*D. caudata*).

There are 309 records of species of Phalacroma from vertical catches. Out of these 309 records 1(0.3%; Station 4664) showed a frequency of 40%; 1(0.3%; Station 4663) 10%; 2(0.6%; Stations 4613, 4666) 6%; 2(0.6%; Stations 4663, 4709) 5%; 2(0.6%; Stations 4590, 4662) 4%; 8(2.5%; Stations 4598, 4664, 4667, 4671, 4695, 4713, 4715, 4742) 3%; 11(3.6%; Stations 4609, 4634, 4638, 4675, 4681, 4689 [2 records], 4697, 4699, 4713, 4740) 2%; 62(20.1%; Stations 4580, 4590, 4594, 4598 [2 records], 4605, 4613 [2 records], 4617, 4634 [2 records], 4637, 4638 [2 records], 4647, 4648 [3 records], 4650, 4651 [2 records], 4655, 4657 [2 records], 4665, 4667, 4671, 4676 [2 records], 4679 [2 records], 4681 [3 records], 4689 [3 records], 4691 [2 records], 4695, 4697, 4699 [3 records], 4701 [3 records], 4705, 4719 [2 records], 4721 [2 records], 4722, 4730, 4732 [2 records], 4734, 4737, 4739 [3 records], 4742) 1%; 220(71.2%) showed a frequency of less than 1%.

There are seventy-four records of species of this genus from surface catches. Out of these seventy-four records 1(1.4%; Station 4546) showed a frequency of 7%; 1(1.4%; Station 4619) 5%; 1(1.4%; Station 4669) 4%; 3(4.1%; Stations

4604, 4542, 4545) 3%; 6(8.1%; Stations 4615, 4624, 4650, 4669, 4675 [2 records]) 2%; 19(25.7%; Stations 4574, 4600 [2 records], 4604, 4617, 4619 [2 records], 4635, 4657, 4664, 4666, 4720, 4731, 4743, 4540, 4541, 4542, 4543, 4545) 1%; 43(58.2%) a frequency of less than 1% or did not have the frequency established.

Coincident occurrence of different species of Phalacroma in catches from 300 (800, 400, 150, 100)–0 fathoms is recorded at the following of the sixty-seven stations mentioned above:— 15 species occurred coincidently at 1 station (1.5%; Station 4730); 12 species at 1 station (1.5%; Station 4681); 11 species at 1 station (1.5%; Station 4734); 10 species at 2 stations (3.0%; Stations 4699, 4701); 9 species at 1 station (1.5%; Station 4740); 8 species at 3 stations (4.5%; Stations, 4713, 4732, 4737); 7 species at 6 stations (9.0%; Stations 4679, 4697, 4705, 4711, 4734, 4742); 6 species at 7 stations (10.4%; Stations 4587, 4637, 4691, 4695, 4709, 4721, 4739); 5 species at 6 stations (9.0%; Stations 4590, 4613, 4634, 4689, 4719, 4722); 4 species at 12 stations (17.9%; Stations 4594, 4598, 4605, 4617, 4638, 4655, 4662, 4664, 4665, 4676, 4683, 4717); 3 species at 9 stations (13.4%; Stations 4583, 4609, 4648, 4650, 4667, 4671, 4707, 4715, 4736); 2 species at 11 stations (16.4%; Stations 4580, 4647, 4651, 4652, 4657, 4661, 4663, 4666, 4675, 4685, 4728).

Coincident occurrence of different species in surface catches is recorded at the following of the forty-five surface stations mentioned above:— 3 species occurred coincidently at 7 stations (15.6%; Stations 4604, 4617, 4619, 4743, 4540, 4542, 4545); 2 species at 15 stations (33.3%; Stations 4592, 4596, 4600, 4635, 4644, 4660, 4664, 4669, 4675, 4676, 4678, 4720, 4731, 4741, 4541).

At the forty-five surface stations just mentioned, there are records of only nine of the thirty-one species found in the material of the Expedition. The number of surface records of each of these nine species is as follows: *Phalacroma doryphorum*, 26 records, 4 of which are from Salpa stomachs; *P. rapa*, 22 records, 2 of which are from Salpa stomachs; *P. cuneus*, 13 records, 2 of which are from Salpa stomachs; *P. favus*, 6 records, 1 of which is from a Salpa stomach; *P. argus*, 2 records, 1 of which is from a Salpa stomach; *P. parvulum*, 2 records; *P. hindmarchi*, 1 record; *P. expulsum*, 1 record (Salpa stomach); *P. lativelatum*, 1 record (Salpa stomach). Thus not less than sixty-one (82.5%) out of the seventy-four surface records refer to three species only. These three species are evenly distributed over the whole area investigated by the Expedition (see p. 55, on the distribution of the surface stations). It may also be mentioned that *P. porodictyum* was taken in a surface haul in Acapulco Harbor, a station not included in the 127 discussed above.

The fact that Phalacroma was found to be evenly distributed throughout the area investigated makes it highly plausible that this genus is fairly evenly distributed throughout all the tropical and subtropical seas. Finally, it may be mentioned that not less than sixteen out of the forty-seven presumably valid species have not been found except in the material of the Expedition.

Historical Discussion and Systematics

Stein (1883, p. 23), who established Phalacroma, gave no diagnoses but confined himself to a few words of comparisons and to the figuring of six new species, viz., *P. nasutum*, *P. operculatum*, *P. porodictyum*, *P. argus*, *P. doryphorum*, and *P. rapa*. Diagnoses of this genus have been published by Bütschli (1885, p. 1009), Delage and Hérouard (1896, p. 385), Schütt (1896, p. 26), Paulsen (1908, p. 19), and Lebour (1925, p. 75). Of these diagnoses the one by Schütt (1896) is by far the most nearly complete and satisfactory. No extensive description and discussion of this genus have been published.

Besides the six specific names established by Stein (1883), the following specific and subspecific names are to be found in the literature:

P. armatum Hensen (1895)
P. hastatum Hensen (1895)
P. operculoides Schütt (1895)
P. globulus Schütt (1895)
P. porodictyum Stein var. *parvula* Schütt (1895)
P. cuneus Schütt (1895)
P. vastum Schütt (1895)
P. vastum var. *acuta* Schütt (1895)
P. mitra Schütt (1895)
P. jourdani (Gourret) Schütt (1895)
P. ovum Schütt (1895)
P. blackmani Murray & Whitting (1899)
P. hindmarchi Murray & Whitting (1899)
P. dolichopterygium Murray & Whitting (1899)
P. rudgei Murray & Whitting (1899)
P. minutum Cleve (1900c)
P. ceratocorys Entz (1902a)
P. ceratocorys var. *tridentata* (Daday) Entz (1902a)
P. acuminatum (Claparède & Lachmann) Zacharias (1906)
P. sphaericum (Stein) Zacharias (1906)
P. lenticula Kofoid (1907a)
P. reticulatum Kofoid (1907a)
P. striatum Kofoid (1907a)
P. ultimum Kofoid (1907a)
P. circumsutum Karsten (1907)
P. hastatum Pavillard (1909)
P. cuncus Stüwe (1909)
P. circumcinctum Kofoid & Michener (1911)
P. favus Kofoid & Michener (1911)
P. fimbriatum Kofoid & Michener (1911)
P. giganteum Kofoid & Michener (1911)
P. limbatum Kofoid & Michener (1911)
P. porosum Kofoid & Michener (1911)
P. praetextum Kofoid & Michener (1911)
P. pulchrum Kofoid & Michener (1911)
P. rotundatum (Claparède & Lachmann) Kofoid & Michener (1911)
P turbineum Kofoid & Michener (1911)
P. arcuatum Hensen (1911)
P. argo Hensen (1911)
P. euter Hensen (1911)
P. obliquum Hensen (1911)
P. propulsans Hensen (1911)
P. rotundatum Hensen (1911)
P. acutum (Schütt) Pavillard (1916)
P. pulchellum Lebour (1922)
P. kofoidi Herdman (1923)
P. rotundatum (Claparède & Lachmann) var. *laevis* (Claparède & Lachmann) Jörgensen (1923)
P. ovatum (Claparède & Lachmann) Jörgensen (1923)
P. parvulum (Schütt) Jörgensen (1923)
P. elongatum Jörgensen (1923)
P. stenopterygium Jörgensen (1923)
P. simulans Jörgensen (1923)
P. pugiunculus Jörgensen (1923)
P. ebriola Herdman (1924)
P. irregulare Lebour (1925)

In the present paper the following new specific names have been established: — *P. apicatum*, *P. bipartitum*, *P. contractum*, *P. cuneolus*, *P. lativelatum*, *P. lens*, *P. mucronatum*, *P. paulseni*, *P. protuberans*, and *P. pyriforme;* and two previously described species, *Dinophysis galea* Pouchet (1883) and *D. expulsa* Kofoid and Michener (1911), have been transferred to this genus.

Several of the species mentioned in the last two paragraphs have been transferred to other genera. Schütt's (1895) transfer of *Dinophysis jourdani* Gourret to Phalacroma and Entz's (1902a) allocation, under the name of *Phalacroma ceratocorys*, are incorrect. This species belongs to Ceratocorys of the tribe Peridinioidae, as has been shown by Kofoid (1910a, p. 183) and by Jörgensen (1911, p. 147). *Ceratocorys tridentata* Daday (1888), which was treated by Entz (1902a) under the name of *Phalacroma ceratocorys* var. *tridentata* (Daday), is so inadequately described and figured that its generic allocation must be considered as uncertain. Zacharias's (1906, p. 536, 530) use of Phalacroma for Dinophysis in designating *Dinophysis acuminata* Claparède and Lachmann and *D. sphaerica* Stein was probably due to slips of the pen, since at the remaining several places in his paper he maintained the original generic allocation of these two species. In any case, it is erroneous; both these species are typical representatives of Dinophysis. Herdman's (1923, p. 34) transfer of *Amphidinium kofoidi* var. *petasatum* Herdman (1922) to Phalacroma, under the name of *P. kofoidi*, is incorrect, since this species has a very small epitheca and since its transverse and longitudinal furrows are very deep and without distinct lists (see the Dinophysidae, p. 32). It may also be mentioned that if this variety is given the status of a species, then its name must be *petasatum* and not *kofoidi*. For the same reasons *Phalacroma ebriola* Herdman (1924) does not belong to this genus; (see the family Dinophysidae, p. 32). The transfer to the genus Phalacroma of *Dinophysis rotundata* Claparède and Lachmann (by Kofoid and Michener, 1911), of *D. ovata* Claparède and Lachmann (by Jörgensen, 1923), and of *D. laevis* Claparède and Lachmann (by Jörgensen, 1923) probably is justified. These primitive forms are on the borderland between Phalacroma and Dinophysis, but they appear to be somewhat more closely related to the former than to the latter. It should be remembered, however, that these two genera merge into each other, and that their separation is almost arbitrary. As to whether *Dinophysis laevis* should be treated as a distinct species or as a variety of *Phalacroma rotundatum* is a question of its own that cannot be settled as yet. *Phalacroma hastatum* Pavillard (1909), although fairly highly differentiated, is of uncertain generic assignment. In the present paper we have followed Jörgensen's (1923,

p. 31) suggestion and have referred it to *Dinophysis hastata* Stein (see p. 269). Apparently with full justification, Jörgensen (1923, p. 3) has made *Phalacroma nasutum* Stein (1883) the type of a new genus, Pseudophalacroma. *Phalacroma ultimum* Kofoid (1907a) has in the present paper been made the type of another new genus, Dinofurcula.

The elevation to the rank of species of *Phalacroma porodictyum* Stein var. *parvula* Schütt (1895) (by Jörgensen, 1923) and of *P. vastum* var. *acuta* Schütt (1895) (by Pavillard, 1916) probably is justified.

Phalacroma arcuatum, *P. argo*, *P. armatum*, *P. euter*, *P. hastatum*, *P. obliquum* *P. propulsans*, and *P. rotundatum* Hensen (1895, 1911) are *nomina nuda*. The identity in the arrangement of the species in the two tables given by Hensen (1911, p. 166, 167) and the great similarity in the names indicate that the new names *P. arcuatum* and *P. argo* were intended for *P. armatum* and *P. argus*. *Phalacroma rotundatum* Hensen (1911) does not refer to *P. rotundatum* (Claparède and Lachmann), since Hensen (1895, 1911) records the latter as *Dinophysis rotundata*. *P. cuncus* Stüwe (1909), which also is a *nomen nudum*, evidently is due to a typographical error and stands for *P. cuneus*.

Phalacroma simulans Jörgensen (1923) is a synonym of *P. favus* Kofoid and Michener (1911); and *P. stenopterygium* Jörgensen (1923) is a synonym of *P. expulsum* (Kofoid and Michener, 1911). Jörgensen (1923, p. 5) suggests that *P. rudgei* Murray and Whitting (1899) "is perhaps only a thick megacytical stage of *Phalacroma rotundatum* var. *laevis*." However, on account of our scant knowledge of the small and rotund species of this genus, it is advisable to treat *P. rudgei*, preliminarily, as a valid species. With regard to *P. ovum* Schütt (1895) and *P. operculoides* Schütt (1895) see p. 118. With regard to *P. galea* (Pouchet, 1883) see p. 121. *Phalacroma irregulare* Lebour (1925) is based exclusively on fission stages with incomplete lists and with the intercalary border not yet absorbed. It must be regarded as too insufficiently known for certainty of specific identification. Finally, Paulsen (1911b, p. 305, fig. 2) figured a specimen, under the name of *Dinophysis rotundata*, which is referable to Phalacroma but not to any of the species known at the present time. For this form we suggest the name *Phalacroma paulseni*, sp. nov.

Under the designation of Phalacroma sp., four specimens have been figured, viz., by van Breemen (1906, pl. 1, fig. 4a, b), by Okamura (1907, pl. 4, fig. 26 and pl. 5, fig. 42), and by Lindemann (1923, fig. 13). P. sp. van Breemen (1906) possibly may be referable to *P. rudgei*, as suggested by Paulsen (1908, p. 19). P. sp. Okamura (1907, pl. 4, fig. 26) has been allocated to *P. apicatum* (p. 111).

P. sp. Okamura (1907, pl. 5, fig. 42) probably belongs to *P. mitra* Schütt (see Okamura, 1912, p. 18), and not to *P. elongatum* as suggested by Jörgensen (1923, p. 11). P. sp. Lindemann (1923) cannot be identified at the present time.

As will be seen from the previous paragraphs, there are at present forty-seven presumably valid species and one variety of Phalacroma, as follows:—

P. acutum (Schütt) Pavillard (1916)
P. apicatum, sp. nov.
P. argus Stein (1883)
P. bipartitum, sp. nov.
P. blackmani Murray & Whitting (1899)
P. circumcinctum Kofoid & Michener (1911)
P. circumsutum Karsten (1907)
P. contractum, sp. nov.
P. cuneolus, sp. nov.
P. cuneus Schütt (1895)
P. dolichopterygium Murray & Whitting (1899)
P. doryphorum Stein (1883)
P. elongatum Jörgensen (1923)
P. expulsum (Kofoid & Michener) nobis
P. favus Kofoid & Michener (1911)
P. fimbriatum Kofoid & Michener (1911)
P. giganteum Kofoid & Michener (1911)
P. globulus Schütt (1895)
P. hindmarchi Murray & Whitting (1899)
P. lativelatum, sp. nov.
P. lens, sp. nov.
P. lenticula Kofoid (1907a)
P. limbatum Kofoid & Michener (1911)
P. minutum Cleve (1900c)
P. mitra Schütt (1895)
P. mucronatum, sp. nov.
P. operculatum Stein (1883)
P. operculoides Schütt (1895)
P. ovatum (Claparède & Lachmann) Jörgensen (1923)
P. ovum Schütt (1895)
P. parvulum (Schütt) Jörgensen (1923)
P. paulseni, sp. nov.
P. porodictyum Stein (1883)
P. porosum Kofoid & Michener (1911)
P. praetextum Kofoid & Michener (1911)
P. protuberans, sp. nov.
P. pugiunculus Jörgensen (1923)
P. pulchellum Lebour (1922)
P. pulchrum Kofoid & Michener (1911)
P. pyriforme, sp. nov.
P. rapa Stein (1883)
P. reticulatum Kofoid (1907a)
P. rotundatum (Claparède & Lachmann) Kofoid and Michener (1911)
P. rotundatum (Claparède & Lachmann) var. laevis (Claparède & Lachmann)
P. rudgei Murray & Whitting (1899)
P. striatum Kofoid (1907a)
P. turbineum Kofoid & Michener (1911)
P. vastum Schütt (1895)

Besides these forty-seven valid species, we have *Phalacroma galea* (Pouchet, 1883), which may be identical with either *P. doryphorum* or *P. circumsutum*, and *P. irregulare*.

All the published descriptions of the species are short and incomplete and have no or but few data of variation for consideration. The descriptions of Kofoid (1907a) and of Kofoid and Michener (1911) are preliminary and based on the same material as those of the present paper. Some of the forty-seven species mentioned above, *e.g.*, *Phalacroma globulus* Schütt and *P. minutum* Cleve, are so incompletely known that their certain specific identification will cause considerable difficulty. Furthermore, the synonymies of some of these species, *e.g.*, those of *P. rotundatum* (Claparède and Lachmann) and of the other species occurring in northern European waters, are so exceedingly complicated that it appears more than doubtful whether anybody will be capable of unravelling them in a satisfactory way. Finally, a few of these species, as conceived in the present paper, are so variable that there are reasons to believe that future

investigators with adequate material at their disposal will find it necessary and feasible to undertake a further systematic subdivision.

The first investigator to attempt a subdivision of Phalacroma (Jörgensen, 1923) divides the genus into six sections, viz., Paradinophysis, Euphalacroma, Cuneus, Argus, Podophalacroma, and Urophalacroma. The species included in these sections are as follows:— Paradinophysis:— *P. rotundatum*, *P. rotundatum* var. *laevis*, *P. rudgei*, *P. ovatum*, and *P. parvulum*. Euphalacroma:— *P. ovum*, *P. porodictyum*, *P. operculatum*, *P. acutum*, and *P. elongatum*. Cuneus:— *P. expulsum*, *P. cuneus*, *P. blackmani*, and *P. striatum*. Argus:— *P. argus*. Podophalacroma:— *P. rapa*, *P. dolichopterygium*, *P. mitra*, *P. favus*, and *P. hindmarchi*. Urophalacroma:— *P. doryphorum*, *P. circumsutum*, *P. pugiunculus*, and *P. pulchrum*. Using Jörgensen's system as a basis, Pavillard (1923a) suggested a division of the genus into two subgenera, Euphalacroma and Paradinophysis. To the first of these he referred four of Jörgensen's sections, viz., Oblongata (nom. nov.), Cuneus, Argus, Podophalacroma. To the second subgenus he referred the remaining two of Jörgensen's sections, viz., Rotundati (nom. nov.) and Urophalacroma.

The situation of the sulcal lists relative to the thecal valves was unknown even to Stein (1883, p. 23). This problem was settled by studies on the closely related genus Dinophysis (see p. 224). Bütschli (1885) and Schütt (1895, 1899) have given fairly extensive accounts of the structure and organization of the thecal wall and of the cell contents.

With regard to the morphological changes that take place in the theca preceding binary fission, it may be mentioned that megacytic specimens were figured by several investigators, *e.g.*, by Stein (1883), Schütt (1895), Murray and Whitting (1899), and Meunier (1910) before Pavillard (1915a, 1916) discussed at length and correctly interpreted this phenomenon. Schütt (1895, p. 148) misunderstood the significance of the intercalary zones, while Meunier (1910, p. 59) gave a short but correct account of these structures. It may also be mentioned in this connection that Pouchet (1894) interpreted megacytic specimens in the genus Dinophysis as prefission stages.

Contributions to our knowledge of the distribution of Phalacroma are to be found in the following papers, not specifying those previously mentioned in this section:— Cleve (1899c, 1900b, 1901a, c, 1902b, 1903b), Daday (1888), Entz (1902b, 1904, 1905), Forti (1922), Gräf (1909), Gran (1912b, 1915), Karsten (1905, 1906, 1907), Lemmermann (1899a, 1901a, 1904, 1905a), Lindemann (1924, 1925), Lloyd (1925), Lohmann (1902, 1908a, 1920), Mangin (1912, 1915), Nathansohn

(1908, 1909, 1910a), Ostenfeld (1898a, 1906, 1915, 1916b), Ostenfeld and Paulsen (1904), Ostenfeld and Schmidt (1901), Paulsen (1904), Pavillard (1905, 1912), Rauschenplat (1900), Schiller (1911a, b, c, 1912), Schmidt (1901), Schröder (1900a, 1906a, 1911), Stüwe (1909), and Whitelegge (1891). None of these papers contains original figures by means of which the correctness of the determinations may be checked. Forti (1922) gives reproductions of previously published figures of the species recorded. Due to the great difficulties implied in the determination of several of the species of Phalacroma and to the broad concept of species held by many of the investigators, much of the data on the distribution of this genus should be accepted tentatively.

References to Phalacroma or minor contributions to our knowledge of this genus are found also in Balbiani (1884c), Bergh (1884), Calkins (1902), Chun (1903), Doflein (1909, 1911, 1916), Forti and Issel (1923, 1924), Hensen (1891), Kofoid (1906c), Lindemann (1923a), Nathansohn (1910b), Oltmanns (1922), Schütt (1893, 1900a), Steuer (1910, 1911), Walther (1893), and Willey and Hickson (1909). Pavillard (1923a) gives a critical review of Jörgensen's (1923) important paper on this group.

Adaptive and Systematic Value of the Characters. Principles used in the Description of the Species

Although Phalacroma is limited largely to tropical, subtropical, and warm-temperate waters of relatively low buoyancy, it is characterized by the fact that the body (theca) is simple in shape, viz., subspheroidal (Schütt, 1895, pl. 2, fig. 12: 1), lenticular (Plate **3**, fig. 3, 5), cuneate (Plate **2**, fig. 5, 8), inversed fig-shaped (Plate **2**, fig. 7), subbiconical (Plate **4**, fig. 1–7), or bilaterally flattened ellipsoidal (Figure 3: 6) and subobovoidal (Figure 11). In no species does the body show adaptations to flotation in the form of pronounced elongation or protuberances as in Amphisolenia, Triposolenia, and certain species of Dinophysis; they maintain themselves in their optimum habitat, *i.e.*, in the upper strata of the sea mainly as follows:— (*1*) they are fairly active swimmers; (*2*) most of them are relatively small; (*3*) their protoplasm contains large pusules (Schütt, 1895, pl. 4, fig. 19: 2) and inclusions of low specific gravity, such as fats and oils (Schütt, 1895, p. 82–86), and they thus have a specific gravity approaching that of the surrounding medium; (*4*) in many of them the surface friction is increased by structural differentiations of the outer surface of the theca (Plate **4**, fig. 1–7); (*5*) some of them have relatively large cingular, sulcal, or para-

sagittal lists (Plate 2, fig. 8; Plate 1, fig. 6; Plate 4, fig. 4; Plate 3, fig. 5; Figure 23: 6).

The most important of these five points probably is the third one, *i.e.*, the lowering of the specific gravity of the body. Without stressing the first point, it is known that the species of Phalacroma are fairly active swimmers, but, on the other hand, there are no data as yet on the question as to how their swimming capacity compares with that of the members of such genera as Amphisolenia and Triposolenia in which the body is highly adapted for flotation. As to the second point, *i.e.*, the relatively small size of the body, it may be mentioned that the largest of all the known species of Phalacroma, *P. giganteum*, is characterized by its thin and fragile theca, while its close relative, the comparatively small *P. cuneus*, has a rather heavy theca. The reduced thickness of the thecal wall in *P. giganteum* may be interpreted as an adaptation to flotation; the decrease in the weight of the theca at least to some extent counterbalances the reduction in the relative surface of resistance caused by the increase in the volume of the body. When the adaptive value of the lists is considered, it should be remembered that these structures are relatively small in all the species of the genus occurring in cold waters (viz., *P. rotundatum* and its variety *laevis*, *P. ovatum*, *P. paulseni*, *P. minutum*, and *P. rudgei*), and that they reach their highest development in waters of low buoyancy. A thorough understanding of the functions of each of the three different kinds of lists present in this genus, viz., the cingular, sulcal, and parasagittal lists, will require a careful analysis from the viewpoints of mechanics and hydrodynamics. Such an analysis is outside the scope of the present paper. The following summary statements must suffice.

The cingular lists, although small, undoubtedly act as parachutes when the body is suspended with the apex uppermost. The nearly symmetrically developed parasagittal lists of some species, *e.g.*, of *P. limbatum* and *P. fimbriatum* (Plate 3, fig. 5; Plate 4, fig. 4), act as parachutes when the organism is turned upon one of its lateral faces. The asymmetrical parasagittal lists of some species, *e.g.*, of *P. pulchrum* (Plate 3, fig. 6), and the asymmetrical left sulcal list increase the surface of resistance and cause the organism to sink in a descending zigzag or spiral path whenever it rests on one of its lateral faces. They also function as keels and rudders, thus stabilizing the progressive spiral swimming characteristic of Phalacroma (*cf.* Kofoid, 1906e, p. 129). Noteworthy in this connection are the small size of the right sulcal list, when compared to the left, and the fact that the left sulcal list is somewhat oblique in position, passing from the left valve to the right, and often somewhat spiral-shaped (Plate 2, fig. 1, of *Phala-*

croma fimbriatum; Plate 5, fig. 3, of *Dinophysis jörgenseni*). Finally, it may be added that the inclination of the longitudinal axis of the body found in several species of Phalacroma may be connected with the spiral mode of swimming. With regard to the significance of the spiral swimming, see Jennings (1901).

Although in the present paper all the external characters have been taken into account in the establishment and characterization of species, some of the specific separations in Phalacroma should be regarded as tentative. This is due partly to the simple organization of many of these species and partly to the fact that all the species characters are subject to variations of the fluctuating kind, in varying degree of amplitude. The characters which are most variable within the species are the size and shape of the body (theca), the relative height of the epitheca, the shape of the left sulcal list, and the development and structure of the accessory lists and sails. These are also the characters which have been most profoundly modified within the genus as a whole, and it is largely upon them that the subdivisions of the genus have been founded. The variations in the development of the parasagittal lists appear at least in part to be due to the comparatively slow formation of these structures following binary fission.

When not otherwise stated, the following principles have been applied in the *descriptions* of species of this genus:—

(*1*) All characteristics refer to specimens in lateral view.

(*2*) Diagnoses and descriptions refer to premegacytic specimens only; when only megacytic specimens were available, descriptions and measurements were made from valves exclusive of the intercalary zone.

(*3*) The terms length and depth of body, and symmetrical and asymmetrical species refer to body (theca) exclusive of lists.

(*4*) When the cingular lists have only the two ribs near the dorsal sagittal suture, they are said to be without ribs.

(*5*) The right sulcal list is without structural differentiations.

If not otherwise stated in the *diagnosis*, the species is characterized by the following features: —

(*1*) The body is subsymmetrical, and its longitudinal axis is perpendicular to the girdle.

(*2*) The thecal wall has scattered pores.

(*3*) In the case of the species figured with the body viewed dorsoventrally, the flagellar pore is located about a girdle-width behind the posterior cingular list.

(*4*) The epitheca is visible above the anterior cingular list.

(*5*) The cingular lists are ribbed, subequal, about as wide as the transverse

furrow, subhorizontal or with but slight anterior inclination, and run in an almost straight line across the body. Their ribs are complete or almost so, *i.e.*, they reach the free edge of the list, equidistant, straight, and simple or almost so.

(*6*) The right sulcal list is subtriangular, and extends to R_2 or to R_3 of the left sulcal list or to a point somewhere between these two ribs.

(*7*) Left sulcal list: the ventral and posterior margins, which are straight or but slightly convex, concave, or sigmoid, form together a distinct angle. The three main ribs are present, of moderate strength, almost straight, and not club-shaped or otherwise modified; and the list has no structural differentiation besides the main ribs.

(*8*) Accessory lists and sails are absent, or, when present, they lack structural differentiations.

The methods of measuring lengths, angles, and proportions utilized are shown in Figure 29.

Subdivisions. Relationships among the Species

Although Phalacroma is one of the most primitive genera of Dinophysoidae, it exhibits a marked structural diversity. Of all the known species, *P. pulchellum* is considered to be, on the whole, structurally the most primitive, resembling the simple ancestors from which this genus originated. This assumption is based on the small size (length, 21 μ) of this species, on its approach to the fundamental spherical form, its large and high epitheca (the posterior cingular list is located about 0.40 the length of the body from the apex), the slight development of its cingular and sulcal lists, its lack of accessory lists and sails, and on the areolation and porulation of its thecal wall. A fundamental feature of the structural differentiation within the genus is that it nearly always has been accompanied by an increase in size. Although the body shows a great variety of shapes, it is never characterized by extreme elongation or by processes; on the other hand, bilateral compression is a nearly universal phenomenon. The girdle is supposed to have been originally nearly equatorial in position (see p. 30). From the equatorial position, which still is found in some of the primitive as well as in some of the advanced species (*P. lenticula*, Figure 3: 7; *P. limbatum*, Plate 3, fig. 5), the girdle has migrated anteriorly; or a reduction in the height of the epitheca has taken place. The cingular lists show increase in size and structural complexity, but remain comparatively small and simple. A somewhat greater diversity in size and structure is exhibited by the left sulcal list. Just as in Ornithocercus and Histioneis, it is largely the portion of this list behind the fission

rib that has increased in size and structural complexity. The phylogenetic development of the accessory lists and sails appears to have proceeded from the posterior end of the left sulcal list anteriorly along the dorsal side of the body, and from the right valve to the left. The structure of the thecal wall seems to have developed in most cases from areolation to reticulation; and there seems to have been an inherent tendency for the meshes of the reticulum to become progressively larger. Sometimes, however, a differentiation of the thecal structure appears to have taken place (*e.g.*, *P. giganteum*).

In most cases the progress within the several groups, which have been established in speciation, is from the less to the greater diversity and specialization in structural detail. This increase in complexity is expressed in several, though not often in all the characters, of the individual species. It is interesting to note how the structural features utilized in speciation in this genus seem to be pervaded by the aspect of factors such as those with which the geneticist deals. In some groups the speciation might be conceived as a series, partially realized, of permutations of factors with intergradations due to multiple factors giving results which simulate seriation. In other groups we find more or less clearly defined orthogenetic series of intermediate and progressively differentiated species. The factorial analyses of genetics do not compel the assumptions that the individual links in these series have originated chronologically, *i.e.*, that they are genetically sequential, although the conventional conception of the evolutionary process inclines us to this interpretation. Nuclear reorganizations equivalent, or related to those which ensue in gametogenesis or endomixis would appear to be an essential cytological basis for the distribution of genes which the kind of speciation outlined above seems to suggest. However, such reorganizations are as yet unknown in this genus.

1. CONTRACTUM group: —

P. contractum, sp. nov. Figure 3: 1.

2. ROTUNDATUM group: —

P. pulchellum Lebour (1922, fig. 1–4).
P. parvulum (Schutt) Jorgensen. Figure 3: 4–6.
P. globulus Schütt (1895, pl. 2, fig. 12).
P. operculoides Schütt (1895, pl. 2, fig. 11: 1).
P. rudgei Murray & Whitting (1899, pl. 31, fig. 6).
P. rotundatum (Claparède & Lachmann) Jörgensen (1923, fig. 2).
P. rotundatum (Claparède & Lachmann) var. *laevis* (Claparède & Lachmann) (1858, pl. 20, fig. 13).
P. irregulare Lebour (1925, pl. 11, fig. 4).
P. lativelatum, sp. nov. Figure 3: 2, 3.
P. paulseni, sp. nov. Paulsen (1911b, fig. 2).
P. ovatum (Claparède & Lachmann). Jörgensen (1923, fig. 3).
P. lens, sp. nov. Figure 4: 1–3.
P. porosum Kofoid & Michener. Figure 5.
P. lenticula Kofoid. Figure 3: 7.

3. Argus group: —

P. porodictyum Stein. Figure 6.
P. vastum Schütt (1895, pl. 3, fig. 16: 3).
P. argus Stein. Figure 8: 1, 2.
P. apicatum, sp. nov. Figure 10.
P. operculatum Stein *s. str.* (1883, pl. 18, fig. 8).
P. circumcinctum Kofoid & Michener. Figure 8: 3.
P. ovum Schütt. Figure 11.
P. elongatum Jörgensen (1923, fig. 9).
P. pyriforme, sp. nov. Figure 4: 4, 5.

4. Cuneus group: —

P. cuneus Schütt. Figure 12.
P. blackmani Murray & Whitting (1899, pl. 31, fig. 4).
P. striatum Kofoid. Figure 14: 3.
P. giganteum Kofoid & Michener. Figure 14: 1.

5. Rapa group: —

P. acutum (Schütt) Pavillard. Schütt (1895, pl. 3, fig. 17: 7).
P. minutum Cleve (1900c, pl. 8, fig. 10, 11).
P. dolichopterygium Murray & Whitting (1899, pl. 31, fig. 8).
P. mitra Schütt (1895, pl. 4, fig. 18).
P. rapa Stein. Figure 16.
P. farus Kofoid & Michener. Figure 14: 2, 4, 5.
P. hindmarchi Murray & Whitting. Figure 18.

6. Expulsum group: —

P. protuberans, sp. nov. Figure 20: 1–5.
P. expulsum (Kofoid & Michener). Figure 20: 6–9.

7. Limbatum group: —

P. limbatum Kofoid & Michener. Figure 21: 1.
P. bipartitum, sp. nov. Figure 21: 2.
P. pulchrum Kofoid & Michener. Figure 21: 3.

8. Doryphorum group: —

P. mucronatum, sp. nov. Figure 22: 4, 6, 8.
P. doryphorum Stein. Figure 23: 1–5.
P. circumsutum Karsten. Figure 23: 6.
P. cuneolus, sp. nov. Figure 23: 1–3, 5, 7.
P. pugiunculus Jörgensen (1923, fig. 19).

9. Praetextum group: —

P. praetextum Kofoid & Michener. Figure 25: 4, 5.

10. Reticulum group: —

P. fimbriatum Kofoid & Michener. Figure 25: 1.
P. reticulatum Kofoid. Figure 25: 2.
P. turbineum Kofoid & Michener. Figure 25: 3.

Discussion of Species Groups

1. Contractum group (Figure 3: 1). The sole member of this group is of uncertain generic assignment. The small size and subrotund shape of the body, the fairly large size of the epitheca, the small size and the shape of the cingular

and sulcal lists, and the lack of ribs in the left sulcal list affiliate it with *Pseudophalacroma nasutum*. The latter species is characterized especially by an anterior prolongation of the longitudinal furrow, extending two thirds the distance from the girdle to the apex. This prolongation, which presumably is a primitive feature of great taxonomic significance, is not indicated in our drawing of *Phalacroma contractum* but may have been overlooked. The small size and simple structure of the cingular and sulcal lists indicate that this species is on a lower evolutionary level than the members of the Rotundatum group.

2. Rotundatum group (Lebour, 1922, fig. 1–4; Figure 3: 4–6; Schütt, 1895, pl. 2, fig. 12, 11: 1; Murray & Whitting, 1899, pl. 31, fig. 6; Jörgensen, 1923,

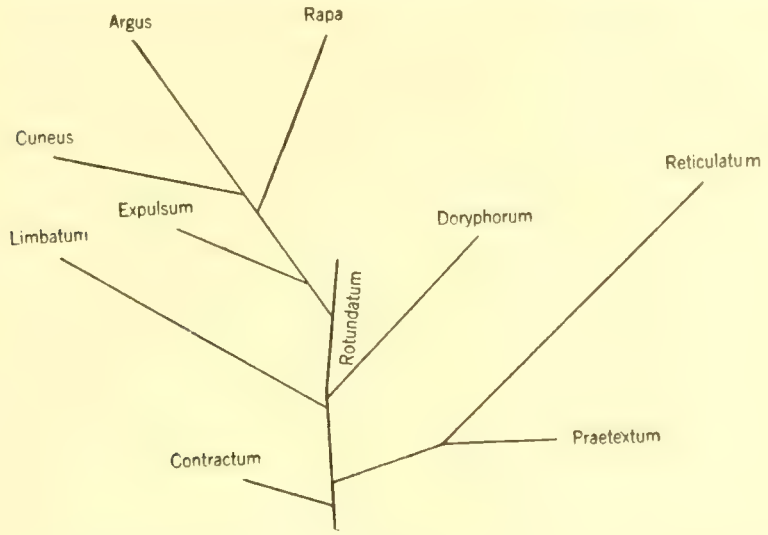

Figure 2.— Graphical representation of the relationships of the groups of species in Phalacroma.

fig. 2; Claparède & Lachmann, 1858, pl. 20, fig. 13; Lebour, 1925, pl. 11, fig. 4; Figure 3: 2, 3; Paulsen, 1911b, fig. 2; Jörgensen, 1923, fig. 3; Figure 4: 1–3; 5: 1–3; 3: 7). Body circular, subcircular, or ellipsoidal in lateral outline; length: depth, 0.95–1.30: 1. Epitheca large to fairly small, depending on position of girdle, which is quite variable; posterior cingular list located 0.16–0.58 the length of body from apex. Longitudinal axis usually perpendicular or nearly so, but it may be somewhat inclined posteroventrally. In dorsoventral view the body is subrotund to more or less narrowly lens-shaped. The cingular lists, which are somewhat wider to somewhat narrower than the transverse furrow and usually without structural differentiation, are either subhorizontal or characterized by a more or less pronounced anterior inclination. Free margin of right sulcal list either almost evenly convex, or nearly straight anteriorly and convex posteriorly. Left sulcal list,

which is very unsatisfactorily represented in some of the members of this group, is probably always furnished with three main ribs and angular at posterior main rib. Accessory lists and sails absent. Thecal wall usually porulate and areolate, but areolation may be lacking or is replaced by a fine-meshed reticulation. Most of the species are small; length, 21–82 μ.

All the members of this group are very simple in shape and structure; and since several of them have overlapping ranges of variation, the present delimitation of species should be regarded as partly tentative; compare, for instance, *Phalacroma parvulum*, *P. lativelatum*, and *P. operculoides* (Figure 3: 2, 3, 4–6; Schütt, 1895, pl. 2, fig. 11: 1). No distinct orthogenetic lines can be distinguished; and the degree of interrelationship among the various members cannot be established, due to the simplicity of their organization. The following evolutionary tendencies are inherent in this group: — increase in the size and bilateral compression of the body, anterior displacement of the girdle and consequent reduction of the size of the epitheca, increase in the size of the cingular and left sulcal lists, decrease in the size of the right sulcal list, and the change of the structure of the thecal wall from areolation to reticulation. Furthermore, in some members the cingular lists tend to become inclined anteriorly. A striking feature of these tendencies is their independence, as will be illustrated by the following examples: — *Phalacroma lenticula* (Figure 3: 7) is advanced in size of body (being the largest member of the group), in having the left sulcal list relatively large, and in having the thecal wall reticulated; on the other hand, its girdle has maintained the primitive subequatorial position and its cingular lists are unusually narrow. *Phalacroma porosum* (Figure 5) is large, its girdle is located anteriorly, and its theca is reticulated; its right sulcal list, on the other hand, is still relatively large. *Phalacroma lativelatum* (Figure 3: 2, 3) is primitive in the size of the body, in the relative size of the right sulcal list, and in the structure of the thecal wall; it is advanced in having the epitheca reduced in size and in the unusually large size of the left sulcal list. The bilateral compression of the body has advanced in this group as far as in any other group of this genus (see, for instance, *P. lens*, Figure 4: 2, and *P. irregulare*, Lebour, 1925, pl. 11, fig. 4c). The tendency of the cingular lists to become subhorizontal in some species and inclined anteriorly in others indicates that this group is close not only to the ancestral forms of Phalacroma but also to those of the closely related genus Dinophysis.

The ROTUNDATUM group (a name previously used by Pavillard, 1916, p. 60, and by Jörgensen, 1923, p. 5) corresponds largely to Jörgensen's (1923) Sectio Paradinophysis, the only difference being that Jörgensen does not include *Phala-*

croma operculoides. This difference, however, is apparent only, and due to the fact that *P. operculoides* Schütt of Jörgensen is identical with *P. ovum* Schütt, nobis (see p. 121).

3. Argus group (Figure 6; Schütt, 1895, pl. 3, fig. 16: 3; Figure 8: 1, 2, and 10; Stein, 1883, pl. 18, fig. 8; Figure 8: 3; and 11; Jörgensen, 1923, fig. 9; Figure 4: 4, 5). Body obovate to subovate in lateral outline; length: depth, 1.11–1.65: 1. Epitheca rounded dome-shaped to conical; large, about as wide as hypotheca or but slightly narrower, and usually rather high; distance from posterior cingular list to apex is 0.25–0.53 the length of body. Hypotheca without ventral corner. Longitudinal axis perpendicular or somewhat inclined posteroventrally; very seldom inclined slightly posterodorsally. In dorsoventral view the body usually is obovate, but it may be biconical or pear-shaped. Cingular lists subhorizontal and subequal, about as wide as or somewhat wider than transverse furrow, with or without ribs. Free margin of right sulcal list often angular, concave anteriorly and convex to straight posteriorly; or it is more or less evenly convex. Left sulcal list with three main ribs; its free margin either angular or rounded at posterior main rib. Parasagittal lists usually absent; triangular posterior sail never developed. Thecal wall either areolate or faintly reticulate; when reticulate, 15–30 meshes border girdle posteriorly. Small to large species, 48–111 μ in length.

Among the members of this group, *Phalacroma porodictyum* (Figure 6) is in several respects the most primitive. The body of this species, which usually is regularly obovate in lateral outline, is in some specimens nearly subcircular; the left sulcal list has the fundamental subrectangular shape and its ribs are simple, well developed, and nearly straight; the thecal wall is finely areolate. On the other hand, this species is advanced in having the free margin of the right sulcal list angular, concave anteriorly and concave to straight posteriorly, a character of the greatest taxonomic importance, since it is found in but few species of the genus. From an ancestral form structurally very close to *P. porodictyum* evolved *P. vastum, P. argus, P. apicatum,* and *P. operculatum s. str.*, all of which are structurally very similar. *Phalacroma vastum* (Schütt, 1895, pl. 3, fig. 16: 3), the sulcal lists of which are of unknown shape and structure, differs from *P. porodictyum* especially in having the thecal wall finely reticulate instead of areolate. *Phalacroma argus* (Figure 8: 1, 2) is more advanced than *P. porodictyum* in having the free margin of the left sulcal list rounded instead of angular posteriorly, the posterior main rib of this list reduced in size, and the thecal wall reticulate. *Phalacroma apicatum* (Figure 10), which resembles *P. argus* in these

characteristics, differs from this species, as well as from *P. porodictyum* and *P. vastum*, in the conical shape of its epitheca. *Phalacroma operculatum s. str.* (Stein, 1883, pl. 18, fig. 8), which is very similar to *P. apicatum* in a great many respects, *e.g.*, in the cone-like shape of the epitheca, differs from *P. vastum*, *P. argus*, and *P. apicatum* in having retained the primitive areolate structure of the thecal wall. (Unfortunately, the right sulcal list is omitted in Stein's figure of the type specimen of this species.)

The four remaining species of this group, viz., *Phalacroma circumcinctum*, *P. ovum*, *P. elongatum*, and *P. pyriforme*, are of somewhat less certain allocation. *Phalacroma circumcinctum* (Figure 8: 3) is structurally closest to *P. apicatum*, which it resembles in the fairly elongate and, in dorsoventral view, subbiconical shape of the body; in the subequatorial position of the girdle; and in the subhorizontal position and the width of the cingular lists. It differs from this species especially in the following respects: — it has retained the primitive, areolate structure of the thecal wall; it has a parasagittal list, a unique feature in this group; the free margin of the right sulcal list is gently sigmoid and that of the left sulcal list is angular posteriorly; and the fission rib of the latter list is T-shaped. The last peculiar character of *P. circumcinctum* recalls *P. ovum* (Figure 11) and may be taken as an indication of the close relationship between these two species. *Phalacroma ovum* is primitive in having the thecal wall finely areolate and the free margin of the right sulcal list gently convex. It is advanced in the anterior displacement of the girdle and in having the fission rib of the left sulcal list T-shaped and the posterior main rib of this list club-shaped. *Phalacroma elongatum* (Jörgensen, 1923, fig. 9) differs from the other members of this group in the pronounced elongation of the body. Its systematic position is uncertain largely because of the fact that its right sulcal list is unknown and of its left sulcal list only the anterior half is known. *Phalacroma pyriforme* (Figure 4: 4, 5) resembles *P. argus* strikingly in the shape of the body in lateral view, in the position of the girdle, and in the rounded shape of the posterior portion of the free margin of the left sulcal list. It differs from all the other members of this group in the pyriform shape of the body in dorsoventral view, a character wherein it approaches the CUNEUS group, to which the ARGUS group undoubtedly is very closely related.

The following tendencies appear to be inherent in the ARGUS group:— the epitheca and the hypotheca, either both or separately, tend to become conical, the girdle to move anteriorly, the longitudinal axis to become deflected posteroventrally, the theca to become reticulate, the free margin of the right sulcal list to become angular, that of the left sulcal list to become rounded posteriorly.

Furthermore, the epitheca as well as the hypotheca tends to develop parasagittal lists, but this tendency is expressed morphologically in one species only, viz., *Phalacroma circumcinctum*. An increase in size can be recorded, although most of the members are of subequal size (compare the size of *P. pyriforme* and that of *P. apicatum*).

This group differs fundamentally from the section Argus established by Jörgensen (1923). The latter group includes but one species, viz., *Phalacroma argus*. *P. porodictyum*, *P. operculatum* s. str., *P. ovum* (= *P. operculoides*, Jörgensen, 1923), and *P. elongatum* are referred by Jörgensen to his section Euphalacroma, a group including, besides these four species, *P. acutum*, which in the present paper has been assigned to the Rapa group.

4. Cuneus group (Figure 12; Murray and Whitting, 1899, pl. 31, fig. 4; Figure 14: 3, and 1). Body cuneate in lateral outline, about as deep as long, and deepest at girdle. Epitheca large but relatively low; very broadly rounded. Posterior cingular list 0.20–0.28 the length of body from apex. Hypotheca more or less cuneate and slightly deflected posteroventrally; its posterior portion fairly broadly to rather narrowly rounded; its dorsal margin straight, slightly convex or concave, or slightly sigmoid, concave anteriorly and convex posteriorly; its postmargin evenly convex and confluent with the dorsal and ventral margins; its ventral margin not angular. In dorsoventral view the body is cuneate, with broadly rounded epitheca, and with the posterior portion of hypotheca narrowly rounded to acute. Cingular lists subhorizontal and subequal, about as wide as transverse furrow, ribbed or reticulate. Free margin of right sulcal list angular, sigmoid, or gently convex. Left sulcal list with the three main ribs developed; its free margin gently convex at posterior main rib and not angular as in most species of this genus; main ribs, especially the posterior, usually more or less weak. Parasagittal lists may be present, but triangular posterior sail never developed. Thecal wall with a reticulum of medium-sized polygons, each of which has a central pore; about twenty-five to thirty-five polygons border girdle posteriorly; reticulation sometimes faint or, perhaps, even absent. Medium-sized to very large species, 72–148 μ in length.

This is the most uniform group within the genus. Its evolutionary differentiation is characterized by the independence of the individual features; in other words, it gives the impression of permutation of characters rather than of orthogenesis. The following facts illustrate this statement. There is a progressive increase in size, but this increase is not paralleled by any other character: *Phalacroma cuneus* is 72–88 μ, *P. striatum* 102–136 μ, *P. blackmani* 125 μ, and *P.*

giganteum 148 μ long. The reticulation of the theca in *P. cuneus*, *P. striatum*, and *P. blackmani* is rather heavy and decidedly better developed than in any of the members of the ARGUS group, a group from which the CUNEUS group presumably originated. In *P. giganteum*, on the other hand, which in regard to size is at the top of its group, the theca lacks reticulation or nearly so. The size of the left sulcal list and the direction of the posterior main rib of this list are about the same in *P. cuneus*, *P. blackmani*, and *P. giganteum* as in *P. argus;* while in *P. striatum*, a species of intermediate size, this list is unusually large and its posterior main rib is directed posteriorly. The right sulcal list has about the same shape, structure, and relative size in *P. striatum* as in *P. argus*. On the other hand, in the small *P. cuneus* this list is long and narrow and its ventral margin is gently convex; and in the large *P. giganteum* it is comparatively small, and its ventral margin is sigmoid instead of angular as in *P. argus*. The parasagittal lists reach their highest development in *P. blackmani*, a species of intermediate size.

The tendencies to be found in this group are as follows: — the body and the left sulcal list tend to increase in size; the reticulation of the thecal wall and the accessory ribbing of the left sulcal list tend to become heavier; the posterior main rib of the left sulcal list tends to become more deflected posteriorly; the free margin of the right sulcal list tends to become angular, concave anteriorly and convex posteriorly; and parasagittal lists tend to develop.

This group corresponds largely to the section CUNEUS established by Jörgensen (1923), the main difference being that Jörgensen includes *Phalacroma stenopterygium* (= *expulsum*), a species assigned by us to the EXPULSUM group. *Phalacroma expulsum* resembles the members of the CUNEUS group in having the hypotheca cuneate in dorsoventral view and the free margin of the left sulcal list rounded instead of angular posteriorly. On the other hand, it differs very strikingly in the small size of the epitheca, in the shoulder-like constriction of the body on the dorsal side of the girdle, and in not having the hypotheca cuneate in lateral outline. Although the members of the EXPULSUM group embody tendencies that affiliate them with the CUNEUS group, they undoubtedly represent a different evolutionary line, and their assignment to the CUNEUS group would decidedly decrease the present homogeneity of this unit.

5. RAPA group (Schütt, 1895, pl. 3, fig. 17: 1; Cleve, 1900c, pl. 8, fig. 10, 11; Murray and Whitting, 1899, pl. 31, fig. 8; Schütt, 1895, pl. 4, fig. 18; Figure 16; 14: 2, 4, 5; and 18). Body subobovate to subcuneate or fig-shaped in lateral outline; length: depth, 1.00–1.34: 1. Longitudinal axis perpendicular or somewhat inclined posteroventrally. Epitheca about as deep as hypotheca or slightly less;

either high and dome-shaped, or more or less flattened. Distance from posterior cingular list to apex 0.10–0.44 the length of body. Hypotheca tapering posteriorly, with a more or less developed corner near middle of ventral side; posterior portion of ventral side (*i.e.*, behind posterior main rib of left sulcal list) almost straight or more or less concave. In dorsoventral view the body is usually cuneate, sometimes fig-shaped, with the posterior portion of hypotheca narrowly rounded to subacute. Cingular lists subhorizontal and subequal, about as wide as transverse furrow, ribbed or reticulate. Free margin of right sulcal list gently convex or this list is of subuniform width throughout the greater part of its length and more or less strongly convex posteriorly. Left sulcal list with three well-developed main ribs; its free margin angular at posterior main rib. Parasagittal lists absent or exceedingly narrow. Thecal wall sometimes areolate but usually reticulate; when reticulate, about twenty to twenty-five meshes border girdle posteriorly. Fairly small to rather large species, 50–98 μ in length.

Phalacroma acutum (Schütt, 1895, pl. 3, fig. 17: 1) is, on the whole, the most primitive member of this group. It is characterized especially by the comparatively high and dome-shaped epitheca and by having the posterior portion of the ventral side of the hypotheca nearly straight; the dorsal margin of the hypotheca is gently and evenly convex; and the thecal wall is finely reticulate. Very closely related to, and possibly identical with, this species is *P. minutum* Cleve (1900c, pl. 8, fig. 10, 11), of which our knowledge, unfortunately, is very fragmentary. Another very close relative is *P. dolichopterygium* Jörgensen (1923, fig. 15), which differs from *P. acutum* mainly in having the epitheca somewhat lower. Since this character is fairly variable within several of the members of Phalacroma, this form too might be specifically identical with *P. acutum*. *Phalacroma dolichopterygium* Murray and Whitting (1899, pl. 31, fig. 8) probably evolved from an ancestral form of about the same shape and structure as *P. dolichopterygium* Jörgensen (1923). These two forms differ from each other mainly in the length of the left sulcal list, which in the specimen figured by Murray and Whitting (1899) extends to the antapex of the body, while in Jörgensen's (1923) it ends just behind the ventral corner of the hypotheca, just as in most of the other members of this group. *Phalacroma dolichopterygium* Jörgensen (1923) also may be considered very similar to the ancestral form from which *P. mitra*, *P. favus*, and *P. rapa* evolved. The most primitive of the three last species presumably is *P. mitra* (Schütt, 1895, pl. 4, fig. 18), which differs from *P. dolichopterygium* Jörgensen (1923) mainly in having the posterior half of the ventral margin of the hypotheca strikingly concave. *Phalacroma rapa* (Figure 16) represents an extreme develop-

ment of the *mitra* type, being characterized especially by the very pronounced angularity of the ventral margin of the hypotheca; the dorsal margin, on the other hand, is still evenly convex, at least in many specimens. *Phalacroma favus* (Figure 14: 4, 5) also may be regarded as an extreme derivative of the *mitra* type; in this species the posterior portion of the body is more or less strongly constricted and thus mammilliform, and the dorsal margin of the hypotheca is undulating. The remaining member of this group, *P. hindmarchi* (Figure 18), must be considered a highly differentiated representative of an evolutionary branch that split off very early, even below the level of *P. acutum*. It has remained primitive in some respects, viz., in the relatively great height of the epitheca and in the structure of the thecal wall, which is areolate; in the latter feature it is even more primitive than *P. acutum*. On the other hand, the posterior portion of its body is as strikingly constricted and mammilliform as in *P. favus*.

Five evolutionary series in this group can be distinguished:—

1. Ancestral form — *P. acutum* — *P. minutum*.

2. Ancestral form — *P. acutum* — *P. dolichopterygium* Jörgensen (1923) — *P. dolichopterygium* Murray and Whitting.

3. Ancestral form — *P. acutum* — *P. dolichopterygium* Jörgensen (1923) — *P. mitra* — *P. rapa*.

4. Ancestral form — *P. acutum* — *P. dolichopterygium* Jörgensen (1923) — *P. mitra* — *P. favus*.

5. Ancestral form — *P. hindmarchi*.

In the four first the epitheca tends to become progressively lower and the posterior portion of the hypotheca to become constricted, mammilliform; the structure of the thecal wall, on the other hand, which is reticulate even in the most primitive known member, viz., *Phalacroma acutum*, does not show any progressive tendencies. In the evolutionary line that led to the development of *P. hindmarchi* the structure of the theca did not even reach the stage characteristic of the four first series but remained areolate, and the tendency to reduce the height of the epitheca was but slightly materialized; on the other hand, the tendency to constrict the posterior portion of the hypotheca was carried to an extreme. It should also be noted that in this group the left sulcal list tends to become decurrent, and its posterior main rib tends to become club-shaped; these tendencies, however, are but seldom materialized (*P. dolichopterygium*, *P. favus*, *P. hindmarchi*). Increase in size is also to be recorded.

This group differs from section Podophalacroma, established by Jörgensen

(1923), only in so far as it does include *Phalacroma acutum* and *P. minutum*, two species assigned by Jörgensen (1923) to his section Euphalacroma. That these two species are more closely related to the members of our RAPA group than to those of our ARGUS group (to which we have referred most of the species assigned by Jörgensen, 1923, to his section Euphalacroma) is strongly indicated by the comparatively heavy reticulation of their thecal wall and by the angularity of the ventral margin of their hypotheca. It should be remembered, however, that we are dealing with very simple organisms, the genetic relationships of which are exceedingly difficult to establish.

6. EXPULSUM group (Figure 20: 1–9). Body sac-like, subobovate, or subcircular in lateral outline, with a dorsal shoulder-like constriction at girdle; length: depth, 1.02–1.24: 1. Longitudinal axis perpendicular or deflected posteroventrally at 1°–10°. Epitheca 0.54–0.76 as deep as hypotheca, low, gently rounded to flat. Posterior cingular list 0.11–0.26 the length of body from apex. In dorsoventral view the body is wedge-shaped, with undulating side contours, and narrowly rounded to acute posteriorly. Cingular lists somewhat narrower to 2.3 times wider than transverse furrow, subhorizontal to inclined anteriorly at 45°, ribbed or without structural differentiation. Right sulcal list subtriangular, its free margin gently convex. Left sulcal list with anterior main rib and fission rib well developed and with posterior main rib vestigial or absent; its free margin rounded posteriorly. Accessory sails and lists absent. Thecal wall with or without reticulation; when reticulation is present it is confined to central portions of valves and 17–20 meshes border girdle posteriorly. Medium-sized species, 53.0–67.4 μ long.

Of the two species included in this group, *Phalacroma expulsum* (Figure 20: 1–5) is the farther advanced, being characterized by a narrower and lower epitheca and by cingular lists of pronounced anterior inclination, two characteristics that affiliate this species with Dinophysis. The structure of the thecal wall shows retrogressive instead of progressive tendencies in this group.

Phalacroma expulsum was assigned by Jörgensen (1923) to the CUNEUS group under the name of *P. stenopterygium*. For a discussion of our attitude on this point, see above, our treatment of the CUNEUS group.

7. LIMBATUM group (Figure 21: 1, 2, 3). Body subcircular in lateral outline; length: depth, 0.99–1.10: 1. Longitudinal axis perpendicular. Epitheca 0.70–0.87 as deep as hypotheca, sometimes high and dome-shaped, sometimes more or less low. Posterior cingular list 0.19–0.50 the length of body from apex. Body strongly compressed bilaterally, ellipsoidal to lens-shaped in outline. Cingular

lists subhorizontal or somewhat inclined anteriorly, subequal, about as wide as transverse furrow, and with or without ribs. Free margin of right sulcal list usually gently convex. Left sulcal list with the three main ribs well developed; its free margin angular at posterior main rib. With posterior triangular sail (or sails) connected with left sulcal list by a well-developed list. Parasagittal lists often present on dorsal side of hypotheca and sometimes on epitheca as well. Thecal wall finely reticulate; reticulation often restricted to central portions of valves. Rather small to medium-sized species, 51–77 μ long.

Of the three members of this group *Phalacroma limbatum* (Plate 3, fig. 5; Figure 21 : 1) is the most primitive in regard to the position of the girdle, which is subequatorial. On the other hand, it is the most advanced in the extension of the parasagittal lists, which encircle not only the hypotheca but also the epitheca. *Phalacroma bipartitum* (Figure 21 : 2), which is intermediate with regard to the position of the girdle, is the farthest advanced in having two, instead of one, posterior sails. *Phalacroma pulchrum* (Figure 21 : 3), which is the smallest member of the group and thus in this respect presumably the most primitive, is farthest advanced in the following respects:— the girdle is located anteriorly and the epitheca is flattened, disk-like; the cingular lists have a fairly pronounced anterior inclination; the list connecting the posterior sail with the left sulcal list is unusually wide.

While the size and shape of the body have been subject to but slight evolutionary changes in this group, there is a pronounced tendency in the girdle to move anteriorly and in the parasagittal lists to increase in size and complexity. Indeed, in no species, except in *Phalacroma fimbriatum*, are the parasagittal lists so large and highly differentiated as in *P. limbatum*. The structure of the thecal wall shows retrogressive rather than progressive tendencies.

The only member of this group included in Jörgensen's (1923) subdivisions of Phalacroma is *P. pulchrum*. This was assigned under the name of *P. circumsutum* Karsten to section Urophalacroma of Jörgensen, a section corresponding largely to our Doryphorum group. It should be noted that *P. circumsutum* Jörgensen (1923) comprises *P. circumsutum* Karsten as well as *P. pulchrum* Kofoid and Michener, and that *P. circumsutum* Karsten is assigned by us to the Doryphorum group. The Limbatum and Doryphorum groups undoubtedly are genetically very closely related, but they should, according to our opinion, be kept separate, since they appear to represent different evolutionary lines. For a discussion of the characters showing a close relationship between *P. pulchrum* and *P. limbatum* see p. 164.

8. DORYPHORUM group (Figure 22: 4, 6, 8; 23: 1–5; 23: 6; and 22: 1–3, 5, 7; Jörgensen, 1923, fig. 19). Body sometimes subrotund but usually obovate to subobovate in lateral outline; length: depth, 1.05–1.28: 1. Longitudinal axis usually perpendicular but sometimes slightly deflected posteroventrally. Epitheca large, slightly narrower than hypotheca, and moderately high to rather low. Distance from posterior cingular list to apex is 0.17–0.41 the length of body. In dorsoventral view the body is either ellipsoidal to obovate or wedge-shaped. Cingular lists usually subhorizontal, but sometimes somewhat inclined anteriorly, subequal, about as wide as the transverse furrow, and ribbed or without structural differentiation. Free margin of right sulcal list gently convex. Left sulcal list with three well-developed main ribs; its margin angular at posterior main rib. With triangular or wedge-shaped posterior sail, which may be connected with left sulcal list by a narrow list. Parasagittal list usually not developed on dorsal side of hypotheca. Thecal wall finely areolate. Small to medium-sized species, 35.0–86.0 μ long.

Phalacroma mucronatum (Figure 22: 4, 6, 8) is the most primitive member of the DORYPHORUM group, and it presumably has about the same habitus as the ancestral forms from which this group originated. The following of its features are more or less primitive: — its small size, the subrotund shape of its body in lateral view, the relatively great height of its epitheca, the fact that its left sulcal list is relatively long and not unusually wide posteriorly, and that the posterior main rib of this list is not club-shaped. Its structurally and probably also genetically closest relative is *Phalacroma doryphorum* (Figure 23: 1–5). This species has advanced in the following respects: — it has increased in size, the body has become obovate, the girdle has been displaced anteriorly, the left sulcal list has increased in width posteriorly and its posterior main rib has become club-shaped, and the posterior sail has increased in size and structural complexity. *Phalacroma circumsutum* (Figure 23: 6) has advanced beyond the *doryphorum* stage mainly in developing a connecting list between the posterior sail and the left sulcal list. *Phalacroma mucronatum* — *P. doryphorum* — *P. circumsutum* may be regarded as an orthogenetic series. *Phalacroma cuneolus* and *P. pugiunculus* (Figure 22: 1–3, 5, 7; Jörgensen, 1923, fig. 19) differ from these species in having the lateral outline of the body somewhat less regular and the posterior sail relatively narrower. *Phalacroma cuneolus* is especially characterized by having the body cuneate in dorsoventral outline, a peculiarity not found in any of the first three species; in *P. pugiunculus* this character is unknown.

The tendencies inherent in the DORYPHORUM group are as follows: — in-

crease in the size of the body, decrease in the height of the epitheca, *i.e.*, anterior displacement of the girdle, increase in the posterior width of the left sulcal list, and in the size and complexity of the posterior sail, development of a connecting list between the posterior sail and the left sulcal list. On the other hand, while in some of the other groups the thecal structure has been subject to evolutionary processes, this feature does not exhibit any tendency to change in the present group. As to the presence of a parasagittal list on the dorsal side of the hypotheca in *Phalacroma circumsutum*, see p. 184.

The DORYPHORUM group corresponds to Jörgensen's (1923) section Urophalacroma with the exception that it does not include *Phalacroma pulchrum*. With regard to this exception see p. 161.

9. PRAETEXTUM group (Figure 25: 4, 5). Body rounded biconical in lateral outline, about 1.12 times longer than deep. Longitudinal axis perpendicular. Epitheca large, about as deep as hypotheca; posterior cingular list 0.51–0.53 the length of body from apex. In dorsoventral view the body is biconical, with rounded apices. Cingular lists subhorizontal, subequal, narrower than transverse furrow, and reticulate. Free margin of right sulcal list gently sigmoid, convex anteriorly and concave posteriorly. Left sulcal list subtriangular, gradually decreasing in width posteriorly; posterior main rib absent. Accessory lists and sails absent. Thecal wall with heavy reticulation; meshes of moderate and subuniform sizes, and about fifteen of them border girdle posteriorly on each valve. The most characteristic feature of this group is a large dumbbell-shaped area or plate on the ventral side of the hypotheca. This plate is cribriform; it has a faint reticulum of very small polygons, each with a fine central pore. The single member of this group is small, 61–62 μ long.

10. RETICULATUM group (Figure 25: 1, 2, 3). Body biconical in lateral outline; length: depth, 1.25–1.84: 1. Longitudinal axis perpendicular, or it has a slight posteroventral deflection. Epitheca large, about as deep as hypotheca; posterior cingular list 0.23–0.45 the length of body from apex. In dorsoventral view the body is biconical, with narrowly rounded to acute apices. Cingular lists subhorizontal, subequal, somewhat wider to somewhat narrower than transverse furrow, ribbed or without structural differentiation. Free margin of right sulcal list gently convex to angular. Left sulcal list merges posteriorly into right parasagittal list; its main ribs not of the type characteristic of most groups of this genus. Parasagittal lists present but without triangular posterior sail. Thecal wall with unusually heavy and large-meshed reticulation; from five to ten polygons border girdle posteriorly. Rather small to large species, 69.5–118.0 μ long.

Of the three species referred to this group, *Phalacroma reticulatum* (Figure

25: 2) and *P. turbineum* (Figure 25: 3) are structurally quite close to each other, while *P. fimbriatum* (Figure 25: 1) occupies a rather isolated position. The first two species are characterized especially by the pronounced biconical shape of the body, by the unusually wide-meshed thecal reticulation (five to eight polygons border girdle posteriorly) and by the narrowness of their parasagittal lists. Peculiarly enough, *P. turbineum*, although smaller, is structurally farther advanced than *P. reticulatum*. Its hypotheca is more elongated, the distance from the apex to the posterior cingular list being 0.23 as compared with 0.40–0.45 the length of the body; the number of polygons along the posterior border of the girdle is only five as compared with seven or eight; and parasagittal lists are present not only on the hypotheca, but also on the epitheca. *Phalacroma fimbriatum*, although the largest member of the group, is characterized by the subequatorial position of the girdle, by the less extreme size of the meshes of the thecal reticulation (about ten of them border the girdle posteriorly), and by the more broadly rounded apices in lateral view. It is farthest advanced not only in the size of the body but also in the size and structural differentiation of the parasagittal lists.

The inherent tendencies to be found in this group are as follows:— increase in the size of the body, anterior displacement of the girdle, development of an extreme biconical, top-like shape, development of large parasagittal lists without a differentiation of triangular posterior sails, increase in the size of the meshes of the thecal reticulation. On the other hand, the left sulcal list tends to remain very small, and its ribs do not show tendencies to develop in the same manner as in most of the other groups of the genus.

In Jörgensen's (1923) subdivisions of the genus Phalacroma no members of the Praetextum and Reticulatum groups were included.

The relationships of these ten groups are represented graphically by Figure 2. As will be seen from this figure, the Rotundatum group is regarded on the whole, as the most primitive; and among its members *Phalacroma pulchellum* is considered as the one most closely approaching the ancestral type from which this genus evolved (see p. 67). The Contractum group represents a small side branch, that originated at a very low level, probably even before the left sulcal list had developed the rectangular shape and the three main ribs characteristic of most of the members of this genus. The Praetextum and Reticulatum groups presumably also branched off before the left sulcal list had developed its typical shape and structure. Of these two groups, both of which are characterized by unusually heavy and wide-meshed thecal reticulation and by the tendency toward a biconical shape of body, the Praetextum group remained relatively

primitive in most respects, *e.g.*, in the size and shape of the body, in the position of the girdle, and in the size of the meshes of the thecal reticulation, while the RETICULATUM group was subjected to profound evolutionary changes. The development of the cribriform plate in the PRAETEXTUM group, however, put this unit in a quite isolated position.

The remaining groups did not branch off until the left sulcal list had developed the shape and structure typical of the ROTUNDATUM group. The DORYPHORUM and the LIMBATUM groups, both of which are characterized by a triangular posterior sail, originated from small ancestral forms of the ROTUNDATUM group, subcircular in lateral outline and with the girdle subequatorial. *Phalacroma mucronatum* (Figure 22: 4, 6, 8) of the DORYPHORUM group is structurally not far removed from these ancestral forms. The ARGUS group appears also to have evolved directly from the ROTUNDATUM group. Indeed, some of its members are structurally fairly close to some of the species of the latter group. From the line that led to the evolution of the top members of the ARGUS group, the CUNEUS, RAPA, and EXPULSUM groups presumably branched off. That the CUNEUS group is very closely related to the ARGUS group is indicated by the following striking similarities between *P. striatum* (Plate 2, fig. 8) and *P. argus* (Figure 8: 1): — (*1*) the longitudinal axis of the body is deflected posteroventrally; (*2*) the free margin of the right sulcal list is concave anteriorly, convex posteriorly, and angular near the middle; its concave anterior portion is strengthened by a marginal rib; (*3*) the left sulcal list has a delicate reticulation, and its free margin is rounded posteriorly, and not angular at the posterior main rib as in most of the species of this genus; (*4*) the thecal wall has a polygonate reticulation, and the polygons are of moderate and subequal size and furnished with a central pore. The RAPA group presumably evolved from an ancestral form fairly similar to *P. vastum* (Schütt, 1895, pl. 3, fig. 16: 3) and *P. porodictyum* (Figure 6) (see p. 67). Of its recent members *P. acutum* (Schütt, 1895, pl. 3, fig. 17: 1) is structurally closest to the ancestral type. *Phalacroma expulsum* (Figure 20: 1–5) shows distinct affiliation with the CUNEUS group in the cuneate shape of the hypotheca in dorsoventral view and in having the posterior portion of the left sulcal list rounded instead of angular as it is in most of the other groups of Phalacroma.

Pavillard (1923a, p. 878) divided Phalacroma into two subgenera as follows:

Euphalacroma	section Oblongata, nom. nov.
	" Cuneus Jörgensen
	" Argus Jörgensen
	" Podophalacroma Jörgensen
Paradinophysis	section Rotundati, nom. nov.
	" Urophalacroma Jörgensen

Sections Oblongata and Rotundati of Pavillard correspond to Jörgensen's (1923) sections Euphalacroma and Paradinophysis, respectively. The adoption of this subdivision is inadvisable since it does not express the evolutionary processes that lead to the development of the various groups. The ROTUNDATUM group is probably just as closely related to the ARGUS group as it is to the DORYPHORUM group (= Urophalacroma). It is probably best, at least for the time being, to keep the groups apart. At the same time it should be pointed out that Pavillard's subgenus Euphalacroma corresponds to our ARGUS, CUNEUS, RAPA, and EXPULSUM groups, all of which are very closely related and evolved from a common ancestral form (Figure 2). If this evolutionary branch is given the status of a subgenus, then subgeneric status must also be given to the CONTRACTUM, PRAETEXTUM, RETICULATUM, ROTUNDATUM, LIMBATUM, and DORYPHORUM groups, and knowledge of the genus Phalacroma does not commend this.

1. CONTRACTUM GROUP. Only one species, *Phalacroma contractum*, belongs to this group.

PHALACROMA CONTRACTUM, sp. nov.

Figure 3: 1

Diagnosis: — Body subcircular in lateral outline, strikingly constricted at girdle, deepest just in front of the middle; length: depth, 1.11: 1. Posterior cingular list 0.33 the length of body from apex. Cingular lists weak, about half as wide as transverse furrow or less. Left sulcal list about 0.44 the length of body; its anterior half of subuniform width and slightly wider than transverse furrow; posteriorly it decreases gradually in width; its margin not angular posteriorly but evenly convex; apparently without ribs or other structural differentiations. Length, 35 μ.

Eastern tropical Pacific.

Description: — A small species, the body of which is subcircular in lateral outline, strikingly constricted at the girdle, and deepest just in front of the middle. The ratio between the length and the depth is about 1.11: 1. The longitudinal axis of the body is about perpendicular to the girdle.

The epitheca is about 0.79 as deep as the hypotheca, strongly and evenly convex, highest in the center, and rather prominent above the anterior cingular list. The transverse furrow is rather strikingly concave, and its width is about 0.43 the greatest height of the epitheca. The posterior cingular list is about 0.33 the length of the body from the apex. The dorsal and posterior margins of the

hypotheca are subsemicircular; the dorsal margin is somewhat bulging just behind the girdle. The ventral margin of the hypotheca is flattened but confluent with the posterior margin. The posterior portion of the body is strikingly wider than the anterior.

The cingular lists are weak, subhorizontal, subequal, about half as wide as the transverse furrow or even somewhat narrower; their structure is unknown. The right sulcal list is unknown. The left sulcal list is about 0.44 the length of the body; its anterior half is of subuniform width and slightly wider than the transverse furrow; posteriorly it decreases gradually in width, and its free margin is not angular posteriorly but evenly convex; according to the available drawing, it is without ribs and other structural differentiations, and the middle portion of its free margin is reflexed in about the same manner as in *Dinophysis lenticula* Pavillard (1916, pl. 3, fig. 6). There are no accessory lists or sails. The structure of the thecal wall is unknown.

Megacytic specimens have not been recorded as yet.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 35.0 μ. Greatest depth of body, 31.4 μ.

Comparisons: — This species is established on a single outline drawing of a specimen in lateral view, and the description given above thus is incomplete in several respects. The following important characters are unknown: — the shape of the body in dorsoventral view, the structure of the thecal wall, the structure of the cingular lists and of the left sulcal list, and the shape and structure of the right sulcal list.

The discussion of the relationships of *Phalacroma contractum* must be postponed until further data about the structure of this species are available. However, it may be pointed out that the size of the body, the position and development of the girdle, and the shape and size of the left sulcal list suggest a rather close relationship to *Pseudophalacroma nasutum* (Stein) Jörgensen. The latter species is characterized especially by an anterior prolongation of the longitudinal furrow which extends about two thirds of the distance from the girdle to the apex, is somewhat dilated anteriorly, and bordered by a rather low and narrow ridge. This prolongation, which probably is a primitive feature of great systematic significance, is not indicated in Figure 3: 1 and it is impossible to decide whether this absence is real or due to an omission. The small size, subcircular shape of body in lateral view, relatively high epitheca, and weak development of lists affiliate this species with the most primitive members of the Dinophysidae.

Occurrence: — *Phalacroma contractum* is recorded at only one of the 127

stations. This station (4711), the type locality, is on the fourth line of the Expedition and in the South Equatorial Drift. The depth is 300–0 fathoms, the surface temperature 75°, and the frequency less than 1% (one specimen).

2. Rotundatum Group. Of the thirteen members of this group only five were found in the material of the Expedition, and these have been arranged in the following order, suggestive of probable evolutionary sequence: — *Phalacroma parvulum*, *P. lativelatum*, *P. lens*, *P. porosum*, and *P. lenticula*.

Phalacroma parvulum (Schütt) Jörgensen

Figure 3: 4, 5, 6

Phalacroma porodictyum Stein var. *parvula* Schütt, 1895, pl. 2, fig. 13: 6. Lemmermann, 1899a, p. 371; 1901a, p. 373. Ostenfeld & Schmidt, 1901, p. 176. Entz, 1902b, p. 94; 1905, p. 111.
Phalacroma parvulum Jörgensen, 1923, p. 7, 8, 9, 45, fig. 4.

Diagnosis: — Body subcircular or subellipsoidal in lateral outline, deepest near the middle; length: depth, 1.05–1.16: 1. Posterior cingular list 0.26–0.43 the length of body from apex. Cingular lists without structure. Left sulcal list 0.45–0.55 as long as body; distance between R_1 and R_3 is 0.33–0.42 the length of body; R_2 is 0.11–0.21, R_3 is 0.24–0.31 the greatest depth of body; margin forms angle of 80°–110° at R_3; R_3 inclined posteriorly at 0°–30°. Theca finely and closely areolate. Length, 34.8–57.5 μ.

Probably of world-wide distribution in tropical, subtropical, and warm-temperate seas.

Description: — A small species, the body of which is subcircular or subellipsoidal in lateral outline, deepest near the middle. The ratio between the length and the depth is 1.05–1.16: 1. In the specimen, Figure 3: 4, this ratio is 1.05: 1; in the specimens, Figure 3: 5, 6, and Schütt, 1895, pl. 2, fig. 13: 6, and Jörgensen, 1923, fig. 4, it is 1.13–1.16: 1. The longitudinal axis of the body is about perpendicular to the girdle.

The epitheca is well and evenly convex, highest in the center, moderately elevated or rather prominent above the anterior cingular list, and about 0.73–0.90 as deep as the hypotheca; in our specimens this ratio is 0.79 (0.73–0.87): 1; in Schütt's (1895) and Jörgensen's (1923) it is 0.87–0.90: 1. The transverse furrow is flat or slightly convex; and its width is 0.40–1.00 the greatest height of the epitheca. In the specimens, Figure 3: 5, 6, the width of the transverse furrow and the height of the epitheca are subequal; in another specimen (Figure 3: 4) and in the specimens figured by Schütt (1895) and Jörgensen (1923) this ratio is 0.40–0.60: 1. The posterior cingular list is 0.26–0.43 the length of the

body from the apex; in one of our specimens and in Schütt's (1895) specimen this ratio is 0.41–0.43: 1; in two specimens (Figure 3: 5, 6) and in Jörgensen's (1923) specimen it is 0.26–0.32: 1. The hypotheca is symmetrical or almost so, subsemicircular or subellipsoidal; its margins are evenly convex and confluent. The anterior and posterior ends of the body are either of about the same width, or either end is slightly wider or narrower than the other.

The cingular lists are subhorizontal, subequal, about as wide as or slightly wider or narrower than the transverse furrow, and without structural differentiation. The right sulcal list ends at a point about midway between the fission rib and the posterior main rib of the left sulcal list (Schütt, 1895, pl. 2, fig. 13: 6), or it extends as far as to the last-mentioned rib (Figure 3: 5); its anterior half is of subuniform width and about as wide as or slightly narrower than the transverse

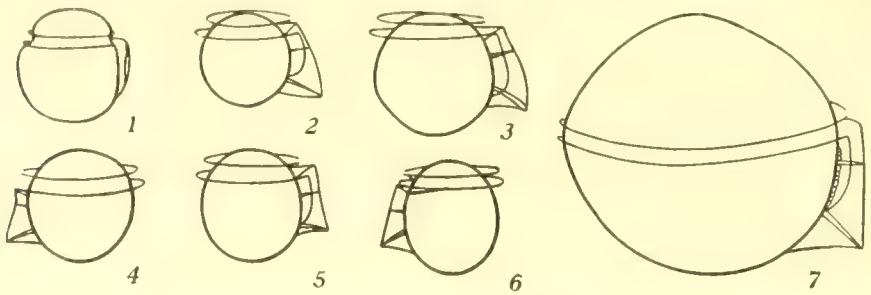

FIGURE 3.— 1, *Phalacroma contractum*, sp. nov., right lateral view of type specimen, Station 4711 (300–0 fathoms). × 430. 2, 3, *Phalacroma latiselatum*, sp. nov., right lateral view. 2, from type specimen, Station 4619, Salpa stomach. × 430. 4–6, *Phalacroma parvulum* (Schütt) Jörgensen. 4, 6, in left lateral view; 5, in right lateral view. × 430. 4, from Station 4724 (300–0 fathoms); 5, from Station 4580 (300–0 fathoms); 6, from Station 4571 (300–0 fathoms); 7, *Phalacroma lenticula* Kofoid, right lateral view of type specimen, Station 4740 (300–0 fathoms). × 430.

furrow; posteriorly it decreases gradually in width. The left sulcal list is 0.50 (0.45–0.55) as long as the body, and the distance between the anterior and posterior main ribs is 0.36 (0.33–0.42) the length of the body. The anterior main rib is 0.16 (0.13–0.22), the fission rib 0.15 (0.11–0.21), and the posterior main rib 0.28 (0.24–0.31) the greatest depth of the body; behind the last rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is rather strikingly sigmoid, concave anteriorly and convex posteriorly (Figure 3: 4; Schütt, 1895, pl. 2, fig. 13: 6); or it is almost straight, or gently concave or convex (Figure 3: 5, 6; Jörgensen, 1923, fig. 4); at the posterior main rib it forms an angle of 90° (85°–110°); behind the last-mentioned rib it is straight or slightly concave or convex. The main ribs of this list are of moderate strength, and not club-shaped or otherwise modified; either all of them are straight or nearly so or the posterior is gently concave posteriorly. The distance between

the anterior main rib and the fission rib is 0.40 (0.30–0.50) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 18°(0°–30°). Except for the main ribs this list appears to lack structure. There are no accessory lists or sails.

The thecal wall is finely and closely areolate, and has scattered pores; the areoles are of about the same size as the pores.

Megacytic specimens have not been recorded.

The dimensions of three of our specimens and of the specimens figured by Schütt (1895) and Jorgensen (1923) were measured.

Dimensions:— Length of body, 34.8–35.6 μ (average, 35.1 μ). Greatest depth of body, 29.5–33.0 μ.

Schütt (1895, pl. 2, fig. 13: 6) does not give the magnification of his figure of the type specimen; however, it probably is 640 times, since this is the magnification of most of his figures of the species of this genus. According to this magnification the type specimen was 48.8 μ long and 42.2 μ deep. Jörgensen's (1923) specimens were 55–56 μ long and 51 μ deep; his specimen figured was 57.5 μ long and 51.0 μ deep.

Variations:— The size of the body, the ratio between the length and the depth of the body, the size of the epitheca, the size of the right sulcal list, and the shape of the left sulcal list are the most variable characters of this species.

Comparisons: — One of the specimens (Figure 3: 4) assigned to *Phalacroma parvulum* agrees very closely with the type specimen of this species as drawn by Schütt (1895, pl. 2, fig. 13: 6). The remaining specimens (Figure 3: 5, 6) show a close agreement with *P. parvulum* Jörgensen (1923, fig. 4). They differ from the type specimen in the relatively lower epitheca and in the almost straight ventral margin of the left sulcal list. We cannot decide as to whether or not Jörgensen's (1923) conception of this species is correct. However, it appears most advisable to accept, preliminarily, his decision in this matter.

Phalacroma parvulum probably is closely related to *P. rotundatum* (Claparède and Lachmann). Indeed, these two species are so similar that their specific separation must be regarded as tentative. Intermediate specimens have been found (Stein, 1883, pl. 19, fig. 9, 10), the specific assignment of which is almost arbitrary. Generally speaking, *P. parvulum* seems to be slightly larger (Jörgensen, 1923, fig. 2, 4), its epitheca seems to be somewhat higher relatively, its anterior cingular list of less anterior inclination, and its left sulcal list relatively wider posteriorly.

It may be mentioned that our present conception of *Phalacroma rotundatum*

is very confused. As a consequence, the synonymy is so complicated that it probably will be impossible to unravel it in an adequate manner. *Dinophysis michaelis* Ehrenberg and *D. laevis* Claparède and Lachmann have been considered as identical with *Phalacroma rotundatum*, and some investigators have changed from one position to another in their choice between these three names, without giving any reasons for doing so. Jörgensen (1923, p. 5) writes about *Phalacroma rotundatum:* "By the above name I designate a variable species, or perhaps a group of species. . . ." A thorough-going revision of this species, as well as of *Dinophysis michaelis* and *D. laevis*, is highly desirable and should be based on material from the Bay of Kiel, the Danish Straits, the Skager Rak, the North Sea, and the west coast of Norway. It should be mentioned that in the original figures of *Phalacroma rotundatum* and *Dinophysis laevis* the left sulcal list is rounded posteriorly, of moderate width, and not wider posteriorly than anteriorly. Later investigators (*e.g.*, Stein, 1883, pl. 19, fig. 9, 10, 11) have assigned to *P. rotundatum* specimens in which the left sulcal list is angular at the posterior main rib and much wider posteriorly than anteriorly. With regard to *Dinophysis michaelis* see p. 240.

Another close relative of *Phalacroma parvulum* is *P. operculoides s. str.* (Schütt, 1895, pl. 2, fig. 11: 1). These two forms also are so similar that their specific separation must be regarded as tentative. The only characteristic in which the last species differs from the first is the shape of the left sulcal list, and this feature is very variable in many species of this genus. However, the data are not sufficient to solve this question.

Phalacroma ovatum (Claparède and Lachmann), *P. lativelatum* nob., and *Dinophysis exigua*, nob. are probably rather closely related to *Phalacroma parvulum*. *Phalacroma ovatum* has about the same habitus as *P. rotundatum*, but it is smaller and has a small antapical spine-like projection (Jörgensen, 1923, p. 6, fig. 3). *Phalacroma lativelatum* differs from *P. parvulum* in the greater width of its left sulcal list; however, it is rather probable that the ranges of variation of these two species overlap. *Dinophysis exigua* is easily distinguished from *Phalacroma parvulum* by the shape of the posterior portion of its left sulcal list and by the posterior inclination of the posterior main rib of this list; another distinctive characteristic is the inclination of the anterior cingular list.

On the other hand, *Phalacroma parvulum* is probably not very closely related to *P. porodictyum*, to which Schütt (1895) referred it as a variety.

Synonymy: — If this species is identical with *P. operculoides* Schütt *s. str.* (see p. 121), then *P. parvulum* becomes a synonym of *P. operculoides*.

Occurrence: — *Phalacroma parvulum* is recorded at seven of the 127 stations. There are 3, 3, 0, 0, 1, and 0 stations on the six lines of the Expedition. Of these seven stations three (4571, 4574, 4580) are in the California Current; one (4635) is in the Panamic Area; two (4648, 4651) are in the Peruvian Current; one (4724) is in the South Equatorial Drift. At two stations (4574, 4635) the species was taken in surface hauls; at one station (4651) in a haul from 800–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms.

The temperature range of these seven stations at the surface was 66°–79°; the average was 73.0°.

At five stations (4574, 4580, 4635, 4648, 4651) the frequency is 1%; at the two remaining stations it is less.

Schütt (1895), who was the first to figure a specimen of this species, did not give any information as to the localities of his material; however, this probably was taken either at Naples, or in the Atlantic. Entz (1902b, 1905) found this species in the Adriatic. Jörgensen (1923, p. 8) writes that it "appears to be frequent throughout the entire Mediterranean." Ostenfeld and Schmidt (1901) recorded it at one station in the Gulf of Aden. Entz, and Ostenfeld and Schmidt do not give any figures or descriptions by means of which their determinations of this species may be checked.

The species probably is eupelagic and of world-wide distribution in tropical, subtropical, and warm-temperate seas. On account of its small size it is but seldom taken with silk nets of the mesh customarily used.

Phalacroma lativelatum, sp. nov.

Figure 3: 2, 3

Diagnosis: — Body subcircular in lateral outline, deepest near the middle; length: depth, 1.04–1.06: 1. Posterior cingular list 0.22–0.33 the length of body from apex. Cingular lists without structure. Left sulcal list 0.57–0.58 as long as body; distance between R_1 and R_3 is 0.43–0.45 the length of body; R_2 is 0.22–0.24, and R_3 is 0.32–0.44 the greatest depth of body; margin forms angle of 80°–90° at R_3; R_3 inclined posteriorly at 20°–30°, sometimes club-shaped. Theca finely and closely areolate. Length, 29.6–37.9 μ.

Eastern tropical Pacific.

Description: — A small species, subcircular in lateral outline, deepest near the middle. The ratio between the length and the depth is 1.04–1.06: 1. The longitudinal axis of the body is about perpendicular to the girdle.

The epitheca is 0.64–0.70 as deep as the hypotheca; it forms almost an arc

of a circle, is highest in the center, and is rather slightly elevated, but visible, above the anterior cingular list. The transverse furrow is flat or slightly convex, and its width about equals or slightly exceeds the greatest height of the epitheca. The posterior cingular list is 0.22–0.33 the length of the body from the apex. The hypotheca is regularly (Figure 3: 2) or slightly irregularly (Figure 3: 3) subcircular. The anterior and posterior ends of the body are of subequal width.

The cingular lists are subhorizontal, subequal, about as wide as or slightly wider than the transverse furrow, and without structure. The right sulcal list extends to or even slightly beyond the posterior main rib of the left sulcal list; it is of subequal width throughout the greater part of its length and rounded posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is 0.57–0.58 as long as the body, and the distance between the anterior and posterior main ribs is 0.43–0.45 the length of body. The anterior main rib is about 0.20, the fission rib 0.22–0.24, and the posterior main rib 0.32–0.44 the greatest depth of the body; behind the last rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is gently convex or gently sigmoid, concave anteriorly and convex posteriorly; at the posterior main rib it forms an angle of 80°–90°; behind the last-mentioned rib it is straight, or gently convex or concave. The main ribs of this list are of moderate strength; either all of them are straight or nearly so, or the posterior is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.30–0.33 the distance between the anterior and posterior main ribs. The posterior main rib, which may be club-shaped (Figure 3: 3), has a posterior inclination of 20°–30°. Except for the main ribs this list appears to lack structure. There are no accessory lists or sails.

The thecal wall is finely and closely areolate, and has scattered pores; the areoles are of about the same size as the pores.

Megacytic specimens have not been recorded.

The proportions of two specimens of the Expedition were measured.

Dimensions:— Length of body, 29.6–37.9 μ (type, 29.6 μ). Greatest depth of body, 27.9–36.6 μ (type, 27.9 μ).

Variations:— The size of the body, the relative size of the left sulcal list, and the shape and structure of the posterior main rib of this list appear to be the most variable characters.

Comparisons:— This species is established on outline drawings of two specimens in lateral view.

Phalacroma lativelatum is closely related to *P. parvulum*. These two forms probably have overlapping ranges of variation, and their specific separation should be regarded as tentative. They differ from each other in the relative size of the left sulcal list. *Dinophysis laevis* [= *Phalacroma rotundatum* (Claparède and Lachmann) var. *laevis* (Claparède and Lachmann) Jörgensen] as conceived by Bergh (1881b, pl. 15, fig. 55) also is closely related to *Phalacroma lativelatum;* the most important difference between these two forms, *i.e.*, the relative size of the left sulcal list, may be due to regulatory changes dependent on the viscosity of the medium. (See p. 87.)

Occurrence: — *Phalacroma lativelatum* is recorded at only one of the 127 stations. This station (4619), the type locality, is on the first line of the Expedition and in the Panamic Area. Two specimens were found in the stomach of a Salpa taken in a surface haul at a temperature of 79°. The frequency was 1%.

Phalacroma lens, sp. nov.

Figure 4: 1, 2, 3.

Diagnosis: — Body subrotund in lateral outline, somewhat constricted at girdle; deepest just behind posterior cingular list or in the middle; length: depth, 1.05–1.11: 1. In dorsal view lens-shaped, widest in the middle, constricted anteriorly, 2.38–2.66 times longer than wide. Posterior cingular list 0.30–0.37 the length of body from apex. Cingular lists sometimes with slight anterior inclination; structure unknown. Left sulcal list 0.45–0.55 the length of body; distance between R_1 and R_3 is 0.32–0.45 the length of body; R_2 is 0.09–0.11, and R_3 is 0.17–0.20 the greatest depth of body; margin forms angle of 90°–100° at R_3; R_3 inclined posteriorly at 10°–25°. Theca finely and closely areolate. Length, 49.0–56.4 μ.

Eastern tropical Pacific.

Description: — A rather small species, with body subrotund in lateral outline, somewhat constricted at the girdle, and deepest just behind the posterior cingular list or in the middle. The ratio between the length and the depth is 1.09 (1.05–1.11): 1. The longitudinal axis is about perpendicular to the girdle.

The epitheca is 0.85 (0.80–0.89) as deep as the hypotheca, moderately elevated above the anterior cingular list, moderately and almost evenly convex, and highest in the center. The transverse furrow is somewhat concave, and its width is 0.45–0.75 the greatest height of the epitheca. The posterior cingular list is 0.33 (0.30–0.37) the length of the body from the apex. The dorsal margin of the hypotheca is evenly, and gently or moderately convex, and confluent with the

postmargin, which is broadly and evenly convex. The ventral margin of the hypotheca either is of about the same convexity as the dorsal margin, or it is more or less flat, or again somewhat irregular as in the specimen represented (Figure 4: 3); it is confluent with the postmargin. The anterior and posterior ends of the body either are of about the same width, or the anterior is somewhat wider than the posterior. In dorsoventral view the outline of the body is lens-shaped, widest in the middle, somewhat constricted in front of the posterior cingular list, and 2.38–2.66 times longer than wide; the side contours of the hypotheca are evenly convex.

The cingular lists are subequal, about as wide as the transverse furrow, and either subhorizontal or with a slight anterior inclination; their structure is unknown. The right sulcal list ends at or somewhat in front of or behind a point midway between the fission rib and the posterior main rib of the left sulcal list; in some specimens it is subtriangular, decreasing gradually in width posteriorly; in other specimens it is subequal in width throughout its anterior half or even throughout the greater portion of its length; anteriorly it is about as wide as or somewhat narrower than the transverse furrow. The left sulcal list is 0.50 (0.45–0.55) as long as the body, and the distance between the anterior and posterior main ribs is 0.40 (0.32–0.45) the length of the body. The anterior main rib is 0.14 (0.09–0.17), the fission rib 0.10 (0.09–0.11), and the posterior main rib 0.18 (0.17–0.20) the greatest depth of the body; behind the last rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is gently concave or nearly straight; at the posterior main rib it forms an angle of 97° (90°–100°); behind the last-mentioned rib it is straight or slightly concave or convex. The main ribs of this list are of moderate strength, straight or nearly so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.25–0.37 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 10°–35°. Structure of list besides the three main ribs unknown. There are no accessory lists or sails.

The thecal wall is finely and closely areolate and has scattered pores; the areoles are of about the same size as the pores.

Megacytic specimens were not found.

The proportions of three specimens were measured.

Dimensions: — Length of body, 49.0–56.4 μ (average, 52.3 μ; type, 56.4 μ). Greatest depth of body, 46.6–50.8 μ (average, 48.1 μ; type, 50.8 μ).

Variations: — Judging by the specimens examined, this species is rather

constant. The shape of the hypotheca in lateral view and the size of the right sulcal list are the most variable characters.

Comparisons: — The species is established on outline drawings of three specimens found in the material of the Expedition.

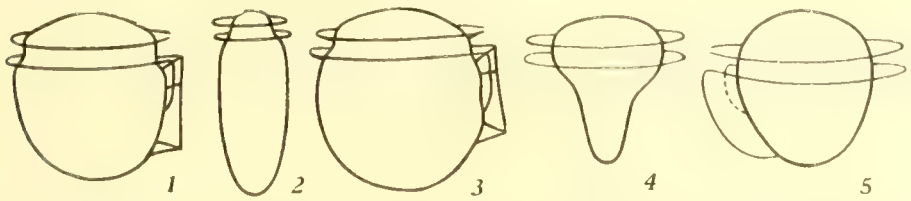

FIGURE 4.— 1, 2, 3, *Phalacroma lens*, sp. nov. 1, 3, in right lateral view; 2, in dorsal view. 2, 3, from type specimen. × 430. 1, from Station 4713 (300–0 fathoms); 2, 3, from Station 4717 (300–0 fathoms). 4, 5, *Phalacroma pyriforme*, sp. nov., type specimen. 4, in dorsal view; 5, in left lateral view, Station 4713 (300–0 fathoms). × 430.

Phalacroma lens probably is rather closely related to *Phalacroma rudgei*, *P. rotundatum*, *P. porosum*, *P. pulchellum*, and to the other subrotund and simple species of this genus. It differs from *P. rudgei* mainly in size (49.0–56.4 μ, as compared with 74 μ), in the anterior constriction of its body in dorsoventral view, and in the areolate structure of its thecal wall. From *P. rotundatum* it may be distinguished by the constriction at the girdle in lateral and dorsoventral views. In *P. porosum* the girdle is gently sigmoid and the sulcal lists are larger than in *P. lens;* and *P. pulchellum* is much smaller (21–33 μ in length), broader in dorsoventral view, and has a smaller left sulcal list. On account of the simplicity of these species, their interrelationships cannot be traced with any high degree of probability.

Occurrence: — *Phalacroma lens* is recorded at three of the 127 stations. There are 0, 0, 0, 1, 2, and 0 stations on the six lines of the Expedition. Of these stations one (4713) is in the Galapagos Eddy, and two (4717, 4730) are in the South Equatorial Drift. Station 4717 is the type locality. All records refer to hauls from 300–0 fathoms.

The temperature range of these three stations at the surface was 73°–79°; the average was 75.9°.

The frequency is less than 1% in all the cases.

PHALACROMA POROSUM Kofoid and Michener

Plate 1, fig. 3, 6. Figure 5

Phalacroma porosa KOFOID & MICHENER, 1911, p. 290.

Diagnosis: — Body subrotund in lateral outline, sometimes subtruncate anteriorly; somewhat deeper anteriorly than posteriorly, deepest at or somewhat

behind girdle; length: depth, 0.99–1.12: 1. In ventral view narrowly obovate. Posterior cingular list 0.20–0.26 the length of body from apex. Girdle crosses lateral faces of body in a sigmoid curve. Cingular lists sometimes slightly inclined anteriorly, without ribs. Left sulcal list 0.52–0.65 the length of body; distance between R_1 and R_3 is 0.36–0.50 the length of body; R_2 is 0.10–0.24, and R_3 is 0.16–0.28 the greatest depth of body; margin forms angle of 90°–110° at R_3; R_3 inclined posteriorly at 10°–35°. Hypotheca with fine reticulation; twenty-five to thirty polygons border girdle posteriorly. Length, 47.9–73.8 μ.

Eastern tropical Pacific.

Description: — A rather small or medium-sized species, the body of which is subrotund in lateral outline, sometimes subtruncate anteriorly, somewhat deeper anteriorly than posteriorly, and deepest at or somewhat behind the girdle. The ratio between the length and the depth is 1.07 (0.99–1.12): 1. The longitudinal axis is about perpendicular to the girdle.

The epitheca is 0.87 (0.78–0.95) as deep as the hypotheca, and moderately or but slightly elevated above the anterior cingular list; sometimes (Figure 5: 1) it is rather strongly convex, sometimes (Figure 5: 2) more or less flattened; in most cases it is highest in the center, but in some specimens somewhat dorsally to the center. The transverse furrow is flat or slightly convex or concave, and its width is 0.66–1.33 the greatest height of the epitheca. The posterior cingular list is 0.23 (0.20–0.26) the length of the body from the apex. The dorsal margin of the hypotheca is evenly and gently convex, and confluent with the postmargin, which is broadly and evenly convex. The ventral margin of the hypotheca either is of about the same convexity as the dorsal margin (Figure 5: 3), or it is somewhat irregular as in Figure 5: 1, 2; it is confluent with the postmargin. In dorsoventral view the outline of the body is narrowly obovate, widest in or just in front of the middle, and with rather narrowly rounded apices; the anterior and the posterior ends are almost of the same width.

The girdle crosses the lateral faces of the body in a sigmoid curve. The cingular lists are subequal, about as wide as the transverse furrow, and either subhorizontal or with a slight anterior inclination; they have, on each valve, only two ribs, one of which is dorsal, the other ventral. The sulcus is about 0.63 as long as the hypotheca. The flagellar pore is located at a distance about equaling its own diameter behind the junction of the cingulum and the sulcus. The right sulcal list ends at, or just in front of or behind the posterior main rib of the left sulcal list; its greatest width about equals or slightly exceeds the width of the transverse furrow; in some specimens it is widest anteriorly, and decreases

gradually in width posteriorly; in others, *e.g.*, in the type specimen, it is widest near the middle, and decreases in width anteriorly and posteriorly. The left sulcal list is 0.58 (0.52–0.65) as long as the body, and the distance between the anterior and posterior main ribs is 0.46 (0.36–0.50) the length of the body. The anterior main rib, when present, is 0.14 (0.12–0.18), the fission rib 0.16 (0.10–0.24), and the posterior main rib 0.22 (0.16–0.28) the greatest depth of the body; behind the posterior main rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list sometimes is almost straight, sometimes gently sigmoid, convex anteriorly and concave posteriorly, and sometimes slightly concave or almost straight anteriorly and posteriorly, and more or less convex or angular at the fission rib (Figure 5: 1; Plate 1, fig. 6); at the posterior main rib it forms an angle of 100° (95°–110°); behind the last-mentioned rib it is straight, or gently concave or convex. The main ribs of

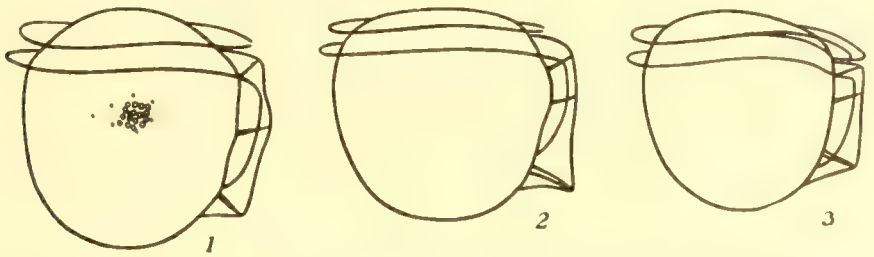

FIGURE 5.— 1–3, *Phalacroma porosum* Kofoid & Michener, right lateral view; structure of surface indicated only on small portion of theca in 1. × 430. 1, from Station 4721 (300–0 fathoms); 2, from Station 4709 (300–0 fathoms); 3, from Station 4681 (300–0 fathoms).

this list are of moderate strength, straight or nearly so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.35 (0.27–0.48) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 25° (10°–35°). With the exception of the main ribs, the left sulcal list lacks structural differentiation. There are no accessory lists or sails.

Except along the dorsal, posterior, and ventral margins, the thecal wall of the hypotheca has a fine reticulum of subequal polygonate meshes; the posterior margin of the girdle is bordered by from twenty-five to thirty polygons. No reticulation has been observed in the epitheca and in the transverse furrow. The whole thecal wall has scattered pores. In the transverse furrow there are two rows of pores, each row with eleven or twelve pores on each valve. The pores are large and prominent and located centrally in relatively heavier polygons.

A megacytic specimen (the type) was recorded.

The proportions of five specimens were measured.

Dimensions: — Length of body, 47.9–73.8 μ (average, 63.0 μ; type, 47.9 μ). Greatest depth of body, 43.5–65.9 μ (average, 59.2 μ; type specimen, 43.5 μ). The type specimen is megacytic; for the sake of comparison, its dimensions and proportions exclusive of the intercalary zone are given. The measurements in the original description of this specimen (Kofoid and Michener, 1911, p. 290) include this zone.

Variations: — Judging by the specimens examined, this species appears to be rather constant. The size of the body, the shape and relative height of the epitheca, the shape of the ventral margin of the hypotheca, and the shape of the ventral edge of the left sulcal list are the most variable characters.

Comparisons: — The description and figures are from the type material.

Phalacroma porosum is probably rather closely related to *P. lens*, *P. rudgei*, *P. rotundatum*, *P. pulchellum*, and to the other small, rotund, and simple species of Phalacroma. However, the distinguishing characteristics of these species are so simple that they afford but little foundation for an estimate of the structural interrelationships. Distinguishing characteristics of *P. porosum* are the size of the body and the shape of the girdle.

Occurrence: — *Phalacroma porosum* is recorded at seven of the 127 stations. There are 0, 0, 1, 1, 4, and 1 stations on the six lines of the Expedition. All these stations (4681, 4709, 4721, 4730, 4732, 4734, 4740) are in the South Equatorial Drift. All the records refer to hauls from 300–0 fathoms.

The temperature range of these seven stations at the surface was 68°–81°; the average was 76.4°.

At one station (4721) the frequency is 1%; at the remaining stations it is less.

The species has been found only in the material of the Expedition. It was first recorded at Station 4721, the type locality. Its absence from surface catches and the fact that all the record stations are located in the South Equatorial Drift are the most noteworthy peculiarities of its distribution in the Eastern Pacific.

Phalacroma lenticula Kofoid

Figure 3: 7

Phalacroma lenticula Kofoid, 1907a, p. 194, pl. 12, fig. 69.

Diagnosis: — Body subcircular in lateral outline, deepest at girdle; length: depth, 0.95: 1. In dorsal view lens-shaped, with subacute apices, widest at girdle, about twice as long as wide. Posterior cingular list 0.58 the length of body from apex. Cingular lists narrow, about half as wide as transverse furrow. Left sulcal list 0.50 the length of body; distance between R_1 and R_3 is 0.27 the

length of body; R_2 is 0.10, R_3 is 0.18 the greatest depth of body; margin forms angle of 90° at R_3; R_3 inclined posteriorly at 45°. Theca finely reticulate. Length, 81.3 μ.

Eastern tropical Pacific.

Description: — A medium-sized species, with the body subcircular in lateral outline, deepest at the girdle, and about as deep as long or even slightly deeper than long. In the type specimen the ratio between the length and the depth is 0.95: 1. The longitudinal axis of the body is deflected posteroventrally at 2°–5°.

The epitheca is about as deep as the hypotheca, highest in or slightly dorsally to the center, subsemicircular or rounded conical, and very prominent above the anterior cingular list. The transverse furrow is flat or slightly convex, and its width is 0.12–0.13 the greatest height of the epitheca. The posterior cingular list is about 0.58 the length of the body from the apex. The hypotheca is semicircular, with evenly convex margins. Posteriorly the body is somewhat wider than anteriorly. In dorsoventral view the body has a regularly lens-shaped outline, with subacute apices, widest at the girdle, and about twice as long as wide.

The cingular lists are subhorizontal, subequal, and about half as wide as the transverse furrow; their structure is unknown. The right sulcal list extends to the posterior main rib of the left sulcal list; it is of subuniform width throughout the greater portion of its length and decreases gradually in width posteriorly; anteriorly it is about as wide as the transverse furrow; it is reticulate along the base. The left sulcal list is about 0.50 the length of the body, and the distance between the anterior and posterior main ribs is 0.27 the length of the body. The anterior main rib, when present, and the fission rib are about 0.10, the posterior main rib is about 0.18 the greatest depth of the body; behind the last rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is nearly straight; at the posterior main rib it forms an angle of about 90°; behind the last-mentioned rib it is nearly straight or slightly concave. The main ribs of this list are of moderate strength, straight or nearly so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is about 0.33 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of about 45°. The structure of this list besides the main ribs is unknown. There are no accessory lists or sails.

The thecal wall has a fine reticulum of subequal polygonate meshes; the posterior margin of the girdle is bordered by thirty-five to forty polygons. Most

of the polygons have a central pore; and in the transverse furrow there are two rows of pores, each row with forty to fifty pores on each valve.

Megacytic stages were not recorded.

The proportions of the type were measured.

Dimensions: — Length of body, 81.3 μ. Greatest depth of body, 86.0 μ.

Comparisons: — The description and drawing are based on the type material.

The species appears to occupy a somewhat isolated position. The subcircular shape of its body in lateral view, the subequatorial position of its girdle, and the narrowness of its cingular lists are characteristics that affiliate it with the most primitive members of this genus, *e.g.*, *Phalacroma globulus* Schütt. On the other hand, it is fairly advanced in size and in the structural differentiation of the thecal wall; and the shape of its body in dorsoventral view, lens-shaped, with subacute apices, widest at girdle, and about twice as long as wide, is unique among the known primitive species of this genus.

Occurrence: — *Phalacroma lenticula* is recorded at six of the 127 stations. There are 0, 2, 1, 1, 1, and 1 stations on the six lines of the Expedition. Of these six stations two (4662, 4664) are in the Peruvian Current; four (4679, 4701, 4724, 4740) are in the South Equatorial Drift. At one station (4662) the species is recorded from 800–0 fathoms. The remaining records refer to hauls from 300–0 fathoms.

The temperature range of these six stations at the surface was 68°–81°; the average was 73.0°.

The frequency is less than 1% in all the recorded cases.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) at Station 4740 (not Station 4749 as stated, Kofoid, 1907a, p. 194). Its absence from surface catches and from the California Current, Mexican Current, and Panamic Area is noteworthy.

3. Argus Group. Of the nine species assigned to this group the following were taken by the Expedition: — *Phalacroma porodictyum, P. argus, P. apicatum, P. circumcinctum, P. ovum,* and *P. pyriforme.*

Phalacroma porodictyum Stein

Figure 6, 7

Phalacroma porodictyum Stein, 1883, pl. 18, fig. 11–14. Bütschli, 1885, pl. 55, fig. 1. Schütt, 1895, p. 93, pl. 2, fig. 13:1–6. Ostenfeld, 1898a, p. 428; 1915, p. 9. Lemmermann, 1899a, p. 319, 371; 1901a, p. 373; 1905a, p. 35. Murray & Whitting, 1899, p. 330, tab. 3. Ostenfeld & Schmidt, 1901, p. 176. Lohmann, 1902, p. 53. Entz, 1902b, p. 94; 1904, p. 14; 1905, p. 111. Pavillard, 1905, p. 59, 81, 102; 1909, p. 283; 1916, p. 47, 48, 54. Karsten, 1906, p. 191. Stüwe, 1909, p. 244, 252, 287.

Hensen, 1911, p. 166. Forti, 1922, p. 106, 190, 208, pl. 7, fig. Jörgensen, 1923, p. 8, 9, 10, 13, 16, 24, fig. 6.

Phalacroma porodyctium Daday, 1888, p. 99 (*lapsu pennae*).

Phalacroma operculatum Schütt, 1895, p. 93, pl. 2, fig. 10: 1–3. Hensen, 1911, *partim*, p. 166, 167, tab. 15.

Phalacroma porodictum Schröder, 1900a, p. 9, 11, 19 (*lapsu pennae*); 1906a, p. 322, 325, 327; 1911, p. 21, 37.

?*Phalacroma porodictyum* Okamura, 1912 (*non* 1907, p. 134), p. 18, pl. 5, fig. 83.

Diagnosis: — Body obovate or subellipsoidal in lateral outline, deepest at or somewhat behind girdle, usually somewhat deeper anteriorly than posteriorly; length: depth, 1.11–1.23: 1; longitudinal axis deflected posteroventrally at 0°–20°. In dorsal view obovate, 1.60–1.80 times longer than wide. Posterior cingular list 0.37–0.50 the length of body from apex. Cingular lists without, or with but faintly indicated ribs. Right sulcal list with angular margin, concave anteriorly, and convex or straight posteriorly. Left sulcal list 0.37–0.53 the length of body; distance between R_1 and R_3 is 0.33–0.40 the length of body; R_2 is 0.09–0.13, and R_3 is 0.10–0.21 the greatest depth of body; margin forms angle of 75°–100° at R_3; R_3 inclined posteriorly at 15°–45°. Theca finely and closely areolate. Length, 72.5–81.5 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is obovate or subellipsoidal in lateral outline, deepest at or somewhat behind the girdle, and 1.11–1.23 times longer than deep. In the Expedition specimens the ratio between the length and the depth is 1.18 (1.14–1.23): 1; in Stein's (1883, pl. 18, fig. 11), 1.14: 1; in Schütt's (1895, pl. 2, fig. 10: 2; 13: 3), 1.11–1.15: 1; and in Jörgensen's (1923, fig. 6), 1.13: 1. The longitudinal axis of the body either is perpendicular to the transverse furrow, as in Stein's (1883) specimen and in some of the Expedition specimens, or it is deflected posteroventrally at an angle of 1°–20°; in the Expedition specimens this deflection does not exceed 8°; in Schütt's (1895, pl. 2, fig. 10_2) it is about 20°, and in Jörgensen's (1923) about 12°.

The epitheca is 0.97 (0.96–0.98) as deep as the hypotheca, strongly and almost evenly convex, in some specimens slightly flattened ventrally or both ventrally and dorsally (Figure 6: 1), dome-shaped, highest at or in some specimens slightly dorsal to the center, and very prominent above the anterior cingular list. The transverse furrow is flat or slightly convex, and its width is 0.20–0.30 the greatest height of the epitheca. The posterior cingular list is 0.37–0.50 the length of the body from the apex; in the Expedition specimens this ratio is 0.47 (0.44–0.50): 1; in Stein's (1883), 0.37: 1; in Schütt's (1895, pl. 2, fig. 10: 2, and 13: 3), 0.38–0.50: 1; and in Jörgensen's (1923), 0.37: 1. The hypotheca is sometimes symmetrical, as in Stein's (1883) specimen and in Figure 6: 1, but usually

it has a more or less pronounced posteroventral inclination (see p. 99). Its dorsal, posterior, and ventral margins are well and evenly convex and confluent. Its posterior portion, which is rather broad in some specimens and rather narrow in others, is nearly always somewhat narrower than the anterior portion of the body. In dorsoventral view (Stein, 1883, pl. 18, fig. 13) the body is regularly obovate, about 1.60–1.80 times longer than wide, and widest at or somewhat behind the girdle; its anterior portion is broadly, its posterior narrowly convex; and its side contours are evenly convex.

The cingular lists are subhorizontal and subequal; they are about as wide as, or slightly wider or narrower than, the transverse furrow, and are "without or with faintly indicated ribs" (Jörgensen, 1923, p. 9). The right sulcal list usually ends at or somewhat behind a point midway between the fission rib and the posterior main rib of the left sulcal list; sometimes it extends even to the last-mentioned rib; in some specimens its ventral margin, even in the widest region, does not quite extend to the ventral margin of the left sulcal list, but in most specimens it does. The anterior half to two thirds of the free margin of this list is more or less concave and sometimes strengthened by a marginal rib; the posterior portion of this margin, which forms a distinct angle with the anterior portion, is more or less convex or almost straight. The greatest width of this list is located just behind the concave portion. The left sulcal list is 0.37–0.53 as long as the body; in the Expedition specimens this ratio is 0.46 (0.44–0.53): 1; in Stein's (1883), 0.40: 1; in Schütt's (1895, pl. 2, fig. 13_3), 0.39: 1; in Jörgensen's (1923), 0.37: 1. The distance between the anterior and posterior main ribs is 0.36 (0.33–0.40) the length of the body. The anterior main rib, when present, is 0.10–0.17, the fission rib 0.08–0.13, and the posterior main rib 0.10–0.21 the greatest depth of the body; in the Expedition specimens these three ratios are 0.12 (0.10–0.13): 1, 0.10 (0.08–0.13): 1, and 0.17 (0.14–0.21): 1; behind the posterior main rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list usually is slightly sigmoid, concave anteriorly and convex posteriorly; sometimes it is nearly straight, or gently concave or convex, or it may be slightly angular at the fission rib (Jörgensen, 1923, fig. 6); at the posterior main rib it forms an angle of 75°–100°; in the Expedition specimens this angle is 93° (90°–100°); in Stein's (1883) about 75°; behind the last-mentioned rib it is almost straight or slightly concave or convex. The main ribs of this list are of moderate strength, straight or nearly so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.35 (0.25–0.45) the distance between the anterior and posterior

main ribs. The posterior main rib has a posterior inclination of 30° (15°–45°). Sometimes this list has a faint reticulation (Stein, 1883; Jörgensen, 1923). There are no accessory lists or sails.

The thecal wall is finely, closely, and usually rather faintly areolate, and has scattered pores. In the transverse furrow there are two rows of pores.

Megacytic stages have been seen by Stein (1883) and Schütt (1895).

The proportions of eight of the Expedition specimens and of those figured by Stein (1883, pl. 18, fig. 11), Schütt (1895, pl. 2, fig. 10: 2, and 13: 3) and Jörgensen (1923, fig. 6) were measured.

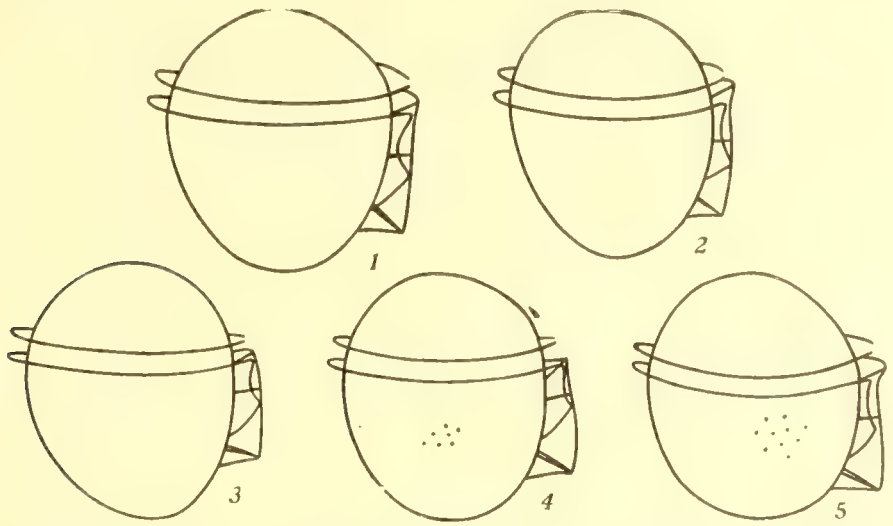

FIGURE 6.— 1–5, *Phalacroma porodictyum* Stein, right lateral view. Porulation indicated only on small portion of theca in 4 and 5. × 430. 1, 2, 3, 5, from Station 4737 (300–0 fathoms); 4, from Station 4739 (300–0 fathoms).

Dimensions: — Expedition specimens: Length of body, 74.8–8.15 μ (average, 77.5 μ). Greatest depth of body, 62.2–69.8 μ (average, 65.8 μ). The size of the type specimen (Stein, 1883, pl. 18, fig. 11) is unknown. According to Stein's (1883) information about the magnifications of his figures, this specimen was somewhere between 73 μ and 112 μ long. The specimens represented by Schütt (1895, pl. 2, fig. 10: 2, and 13: 3) are about 76–78 μ long. The length of Jörgensen's (1923, fig. 6) specimen is about 72 μ. According to Lohmann (1902, p. 53), the length varies between 58 μ and 76.5 μ. This statement, which implies a striking variability in size, has been disregarded in the present paper, since Lohmann does not give any figures or description by means of which his conception of the species might be checked.

Variations: — The variability of this species, as conceived here and by Jörgensen (1923), is rather striking. However, there seems to be but little doubt

that we are dealing with a natural systematic unit. The different forms represented by Figure 6 and by the figures of previous investigators appear to be connected by continuous series of intermediate forms and are probably modifications. The size of the body, the inclination of the longitudinal axis of the body, the relative height and the shape of the epitheca and of the hypotheca, and the shape and size of the left sulcal list are the most variable characters.

Comparisons: — None of the specimens found in the material of the Expedition and determined as *Phalacroma porodictyum* agrees completely with the type specimen of this species as figured by Stein (1883, pl. 18, fig. 11). However, some of these specimens (Figure 6: 1) approach the type so closely that their assignment can be regarded as certain. They differ from the type mainly in having the epitheca somewhat higher relatively and the left sulcal list somewhat longer. Other specimens (Figure 6: 3) are rather similar to Schütt's (1895, fig. 10: 2) and to Jörgensen's (1923, fig. 6) but we have not seen any specimens that show a complete agreement with any of the figures of these two authors.

Phalacroma porodictyum is probably most closely related to *P. argus*. This relationship is indicated by the close resemblance in the size and shape of the body, and in the shape and structure of the right sulcal list. The first species differs from the last mainly in the angularity of its left sulcal list and in the areolate structure of its thecal wall. In both these characters it probably is the more primitive. For further discussion, see p. 107.

Phalacroma porodictyum is certainly specifically distinct from *P. parvulum*, a form which Schütt (1895) first figured as a variety of *P. porodictyum*, and which Jörgensen (1923, p. 7) established as a distinct species.

Synonymy: The specimens figured as *Phalacroma operculatum* Stein by Schutt (1895, pl. 2, fig. 10) probably are referable to *P. porodictyum*. The specimen represented by Okamura (1907, pl. 4, fig. 26) under the designation *P.* sp. . . . *Phalacroma porodictyum* Stein? undoubtedly belongs to *P. apicatum* nob. *Phalacroma porodictyum* Okamura (1912, fig. 83) is probably not identical with *P. porodictyum* Stein, since the specimen figured is very small, about 47 μ long, and has a left sulcal list which is more than twice as wide at the posterior main rib as it is anteriorly.

Hensen (1911, p. 166) writes that he has partly confused *Phalacroma porodictyum* and *P. operculatum*. These two species probably have been confused by several investigators, but the extent of this confusion cannot be established, since only a few authors give figures or descriptions. It may be mentioned in this connection that Cleve never recorded *P. porodictyum*, although he carried out extensive investigations on the plankton of the seas from which this species has been recorded repeatedly. On the other hand, Cleve has numerous records of *P. operculatum*.

Occurrence: — *Phalacroma porodictyum* is recorded at twenty-nine of the 127 stations. There are 5, 5, 6, 5, 8, and 0 stations on the six lines of the Expedition. Of these twenty-nine stations, four (4587, 4590, 4598, 4605) are in the Mexican Current; three (4613, 4634, 4637) in the Panamic Area; five (4648, 4662, 4666, 4673, 4676) in the Peruvian Current; four (4689, 4691, 4697, 4699) in the

Easter Island Eddy; one (4713) in the Galapagos Eddy; and twelve (4679, 4681, 4701, 4705, 4719, 4721, 4724, 4730, 4732, 4734, 4737, 4739) in the South Equatorial Drift. At one station (4713) the species is recorded from 150–0 fathoms; at two stations (4662, 4666) from 800–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms.

The species is also recorded from surface waters in Acapulco Harbor, off the Mexican Current. This station is not included in the 127 stations mentioned above.

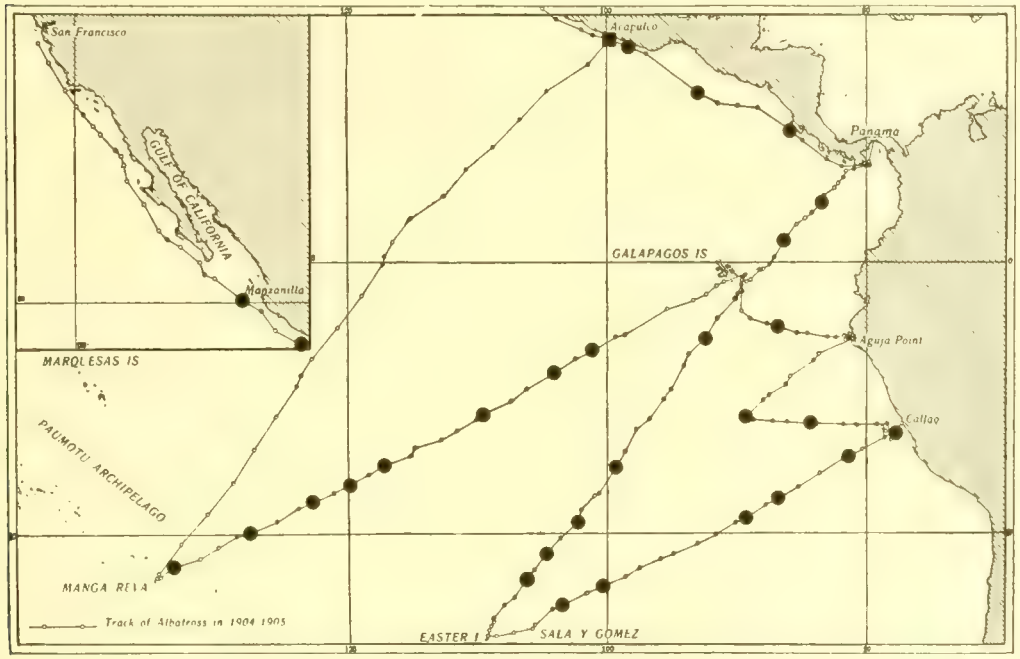

FIGURE 7.— Occurrence of *Phalacroma porodictyum* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

The temperature range of these twenty-nine stations at the surface was 67°–85°; the average was 75.5°. At Acapulco the surface temperature was 83°.

The frequency is 1% at seven stations (4634, 4648, 4679, 4681, 4689, 4699, 4719). At the remaining stations it is less than 1%.

The species was first recorded by Stein (1883) "aus dem Atlantischen Meer und der Südsee." The specimens of this species drawn by Schütt (1895) probably were taken either at Naples, or in the tropical or subtropical regions of the Atlantic. In the Atlantic it was found by the following investigators:— Jörgensen (1923), in the Bay of Cadiz; Murray and Whitting (1899), at lat. 37° 44′ N., long. 30° 55′ W.; Ostenfeld (1898a), at lat. 35° 44′ N., long. 38° 03′ W.; Stüwe (1909), at lat. 28° 30′ N., long. 40° 16′ W.; Karsten (1906), at lat. 0° 9′ S.,

long. 8° 29′ W.; Hensen (1911), localities not specified. From the Mediterranean it is recorded by Pavillard (1905, 1916), in the Gulf of Lyons; Forti (1922), in the Ligurian Sea; Daday (1888) and Schröder (1900a), at Naples; Schröder (1906a), in the Ionian Sea; Entz (1902b, 1905) and Schröder (1911), in the Adriatic Sea; Jörgensen (1923), "throughout the entire Mediterranean." In the Red Sea it was found by Ostenfeld and Schmidt (1901); in the Gulf of Aden by Ostenfeld and Schmidt (1901) and Schröder (1906a); in the Arabian Sea by Ostenfeld and Schmidt (1901) and Schröder (1906a); off the coast of Celebes by Ostenfeld (1915); in the Peruvian Current by Lemmermann (1899a). With regard to Okamura's (1912) records from Japanese waters, see p. 102.

The species was found in waters of the following temperatures: — 74° (Murray and Whitting, 1899), 77.0°–80.3° (Ostenfeld and Schmidt, 1901), and 75.2° (Stüwe, 1909).

Of the investigators who have contributed to a knowledge of the distribution of this species only Stein (1883), Forti (1922), and Jörgensen (1923) give descriptions or drawings of this form by means of which their determinations may be checked.

Phalacroma porodictyum is eupelagic and evidently widely distributed in tropical, subtropical, and warm-temperate seas. In the area investigated by the Expedition it appears to be of almost uniform occurrence. Its optimum habitat according to the records is in deeper waters, within the levels of photosynthesis. It was found at the surface at only one Expedition station, viz., Acapulco.

Phalacroma argus Stein

Figure 8: 1, 2; 9

Phalacroma argus Stein, 1883, p. 18, fig. 15–17. Schütt, 1895, p. 13, 83, pl. 3, fig. 15: 1–3. Lemmermann, 1899, p. 372; 1901a, p. 372. Cleve, 1901a, p. 16. Ostenfeld & Schmidt, 1901, p. 175. Entz, 1902b, p. 94; 1905, p. 111. Schröder, 1906a, p. 324, 327. Karsten, 1907, p. 235. Pavillard, 1909, p. 283; 1916, p. 52. Hensen, 1911, p. 166, 167, tab. 15. Jörgensen, 1923, p. 13, fig. 13.
Phalacroma argo Hensen, 1911, p. 167 (*lapsu pennae*).

Diagnosis: — Body slightly obovate in lateral view, deepest at or somewhat behind girdle; length: depth, 1.15–1.48: 1; longitudinal axis deflected posteroventrally at 0°–12°. In ventral view obovate, widest somewhat behind girdle; length: width, 1.75: 1. Posterior cingular list 0.28–0.45 the length of body from apex. Cingular lists usually without ribs. Right sulcal list with angular margin, concave anteriorly and convex posteriorly. Left sulcal list 0.45–0.59 the length of body; distance between R_1 and R_3 is 0.33–0.43 the length of body; R_2 is 0.07–0.14 and R_3 is 0.09–0.11 the greatest depth of body; margin gently sigmoid, con-

cave anteriorly, convex posteriorly, seldom evenly convex throughout; R_3 inclined posteriorly at 25°–50°. Theca usually reticulate; 15–20 polygons border girdle posteriorly. Length, 83.5–110.5 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized or rather large species, the body of which is obovate in lateral view, deepest at or in most specimens somewhat behind the girdle and 1.15–1.48 times longer than deep. In the Expedition specimens the ratio between the length and the depth of the body is 1.17–1.25: 1; in Stein's (1883, pl. 18, fig. 15, 16), 1.32–1.48: 1; in Schütt's (1895, pl. 3, fig. 15: 1), 1.15: 1; and in Jörgensen's (1923, fig. 13), 1.21: 1. The longitudinal axis either is perpendicular to the transverse furrow, as in Stein's (1883) and in some of the Expedition specimens, or it is deflected posteroventrally at an angle of 1°–12°; in none of the Expedition specimens is it deflected more than at 4°; in those figured by Schütt (1895) and Jörgensen (1923) the deflection is 8°–12°.

The epitheca is 0.87–0.96 as deep as the hypotheca, strongly and almost evenly convex, dome-shaped, highest at or just dorsal to the center, and very prominent above the anterior cingular list. The transverse furrow is flat or slightly convex; and its width is 0.22–0.35 the greatest height of the epitheca. The posterior cingular list is 0.28–0.45 the length of the body from the apex; in the Expedition specimens the corresponding figures are 0.43–0.45; in Stein's (1883), 0.28–0.32; in Schütt's (1895), 0.32; and in Jörgensen's (1923), 0.37. The hypotheca is sometimes symmetrical, as in Stein's (1883) specimens and in Figure 8: 2; but usually it has a more or less pronounced posteroventral inclination (see above). Its dorsal, posterior, and ventral margins are well and evenly convex and confluent. The posterior end of the body is nearly always somewhat narrower than the anterior. In the specimens represented by Stein (1883, pl. 18, fig. 15) and Schütt (1895, pl. 3, fig. 15: 1) the anterior and the posterior portions of the body are of about the same width. In dorsoventral view (Stein, 1883, pl. 18, fig. 17) the body is regularly obovate, about 1.75 times longer than wide, and widest at or somewhat behind the girdle; its anterior end is broadly, its posterior end narrowly, convex; and its side contours are evenly convex.

The cingular lists are subhorizontal and subequal; their width usually about equals or slightly exceeds the width of the transverse furrow; occasionally it is somewhat less. In most specimens these lists appear to lack ribs, but in specimens of well-developed thecal reticulation, they have basally "irregular, coarse and short radial beams, finally anastomosing into an incomplete, wide-meshed reticulation" (Jörgensen, 1923, p. 13). The right sulcal list extends to or some-

what beyond a point midway between the fission rib and the posterior main rib of the left sulcal list; in some specimens its ventral margin, even in the widest region, does not quite extend to the ventral margin of the left sulcal list, but in others it does. The anterior half to two thirds of the free margin of this list is more or less concave and, at least in some specimens, is strengthened by a marginal rib; the posterior portion of this margin, which forms a distinct angle with the anterior portion, is more or less convex or, seldom, almost straight. The greatest width of this list is located just behind the concave portion. The left sulcal list is 0.45–0.59 as long as the body; in the Expedition specimens this ratio is 0.45–0.53: 1; in Stein's (1883), 0.51–0.59: 1; in Schütt's (1895), 0.54: 1; in Jörgensen's (1923), 0.45: 1. The distance between the anterior and the posterior main ribs is 0.33–0.43 the length of the body. The anterior main rib, when present, is 0.07–0.14, the fission rib 0.07–0.14, and the posterior main rib 0.09–0.11 the greatest depth of the body; in the Expedition specimens these three ratios are 0.09–0.14: 1; 0.08–0.09: 1; and 0.09–0.11: 1. The greatest width of this list, which in most specimens is located about midway between the fission rib and the posterior main rib, is 0.10–0.15 the greatest depth of the body. The free margin of this list is gently sigmoid, concave anteriorly and convex posteriorly, seldom gently and evenly convex throughout (Stein, 1883, pl. 18, fig. 15, 16); in other words, it is not angular posteriorly as in most species of the genus, but gently and evenly convex. The main ribs of this list are straight and comparatively weak, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.32–0.45 the distance from the anterior to the posterior main rib; in the Expedition specimens this ratio is 0.41–0.42: 1. The posterior main rib has a posterior inclination of 25°–50°; this angle in the Expedition specimens is 30°–35°; in Stein's (1883), 40°; in Schütt's (1895), 25°; and in Jörgensen's (1923), 50°. There are no ribs except the three main ribs, but sometimes the list appears to be delicately reticulate. There are no accessory lists or sails.

The thecal wall has a polygonate, sometimes but slightly developed, reticulation. There are fifteen to twenty polygons on each valve bordering the posterior margin of the girdle. Each polygon has a central pore. In the transverse furrow there are two rows of pores (and polygons, if present), each row with fifteen to twenty pores on each valve.

Megacytic stages have been found by Jörgensen (1923, p. 13).

The dimensions of two of the Expedition specimens and of the specimens drawn by Stein (1883, pl. 18, fig. 15, 16), Schütt (1895, pl. 3, fig. 15), and Jörgensen (1923, fig. 13) were measured.

Dimensions: — Expedition specimens: Length of body, 83.5–86.2 μ. Greatest depth of body, 66.9–73.5 μ. We do not know the size of the two specimens figured by Stein (1883, pl. 18, fig. 15, 16), one of which is the type. According to Stein's information about the magnifications of his figures, these specimens were somewhere between 80 μ and 145 μ long; the type specimen (Stein, 1883, pl. 18, fig. 16) was somewhere between 94 μ and 145 μ long. The specimen represented by Schütt (1895, pl. 3, fig. 15) is about 110.5 μ long and 96.1 μ deep; the one figure by Jörgensen (1923, fig. 13) is about 91.2 μ long and 75.7 μ deep; *i.e.*, these specimens are slightly larger than those found by the Expedition in the Pacific Ocean.

Variations: — *Phalacroma argus* is rather strikingly variable in the following characters: — the size of the body, the inclination of the longitudinal axis of the body, the relative depth of the body, the relative height of the epitheca, and the

FIGURE 8.— 1, 2, *Phalacroma argus* Stein, right lateral view. Surface markings, faint reticulation, and porulation, indicated only on small portion of theca in 1. × 430. 1, from Station 4730 (300–0 fathoms); 2, from Station 4724 (300–0 fathoms). 3, *Phalacroma circumcinctum* Kofoid and Michener, right lateral view of type specimen, slightly tilted. × 430. Station 4671 (300–0 fathoms).

shape of the sulcal lists. The variations in the inclination of the longitudinal axis of the body are probably exaggerated due to the tilting of some of the specimens examined.

Comparisons: — Stein (1883, pl. 18, fig. 15, 16) figures two specimens of *Phalacroma argus*, one relatively small and dorsoventrally narrow, the other relatively large and deep. The specimens in the material of the Expedition agree rather closely with the last-mentioned specimen (Stein, 1883, fig. 16). They differ mainly in the following respects: — (*1*) the epitheca is relatively higher; (*2*) the ventral margin of the left sulcal list is not evenly convex but sigmoid, being gently concave anteriorly and convex posteriorly. In most of the Expedition specimens the longitudinal axis of the body is deflected somewhat posteroventrally, while in Stein's specimen the body is symmetrical. The differences, however, are too small to be considered as specific. Moreover, it should be noted that the relative

height of the epitheca, the shape of the ventral margin of the left sulcal list, and the inclination of the longitudinal axis of the body are characters subject to rather striking variability in the species of the ARGUS group (*P. apicatum*, Figure 10).

The specimens of *Phalacroma argus* figured by Schütt (1895, pl. 3, fig. 15) and by Jörgensen (1923, fig. 13) agree very closely with most of the ALBATROSS specimens of this species. They differ mainly in having the longitudinal axis of the body deflected somewhat more posteroventrally, at 8°–12° as compared with 1°–4°; they agree fairly closely with the specimen represented by Stein (1883, pl. 18, fig. 16). This specimen therefore should be regarded as the type of *Phalacroma argus*. The question as to whether or not the two forms represented by Stein (1883) under this name are different genetically cannot be settled as yet. Preliminarily, Jörgensen's (1923) broad conception of this species is adopted.

Judging by the great similarities in the shape and structure of the cingular and sulcal lists and in the structural differentiation of the thecal wall, *Phalacroma argus* is probably more closely related to *P. apicatum* than to any other known member of the genus. Indeed, these two forms are so similar that even their specific separation is questionable, and the solution suggested should be regarded as tentative. *Phalacroma argus* differs from *P. apicatum* mainly in having relatively lower, well-rounded, and dome-shaped epitheca.

Phalacroma porodictyum Stein, as conceived in the present paper and by Schütt (1895) and Jörgensen (1923), is probably, next to *P. apicatum*, the nearest-known relative of *P. argus*. This relationship is indicated by the close resemblance in the size and shape of the body and in the shape and structure of the right sulcal list. *Phalacroma porodictyum* is easily distinguished from *P. argus* and *P. apicatum* by the angularity of the posterior portion of its left sulcal list and by the structure of its thecal wall.

Probably another close relative of *Phalacroma argus* is *P. striatum*. This species, which is a member of the rather highly differentiated CUNEUS group, resembles *P. argus* in the following respects: — (*1*) The longitudinal axis of the body is deflected posteroventrally. (*2*) The free margin of the right sulcal list is concave anteriorly and convex posteriorly. Its concave anterior portion, which forms a distinct angle with the posterior portion, is strengthened by a marginal rib. (*3*) The left sulcal list is delicately reticulated. Its free margin is well rounded posteriorly, and not angular at the posterior main rib as in most of the species of this genus. (*4*) The thecal wall has a polygonate reticulation. The polygons are of moderate size and each of them has a central pore. *Phalacroma*

striatum is easily distinguished from *P. argus* by its low epitheca, its broad, somewhat wedge-shaped hypotheca, and its exceptionally large left sulcal list. The CUNEUS group probably originated from an ancestral form of about the same habitus as *P. argus*, just as this last species probably originated from a form resembling *P. porodictyum*.

From the comparatively simple structure of *Phalacroma argus*, it seems probable that its closest relatives, next to *P. apicatum*, *P. porodictyum*, and *P. striatum*, should be sought among those members of the genus which are pre-

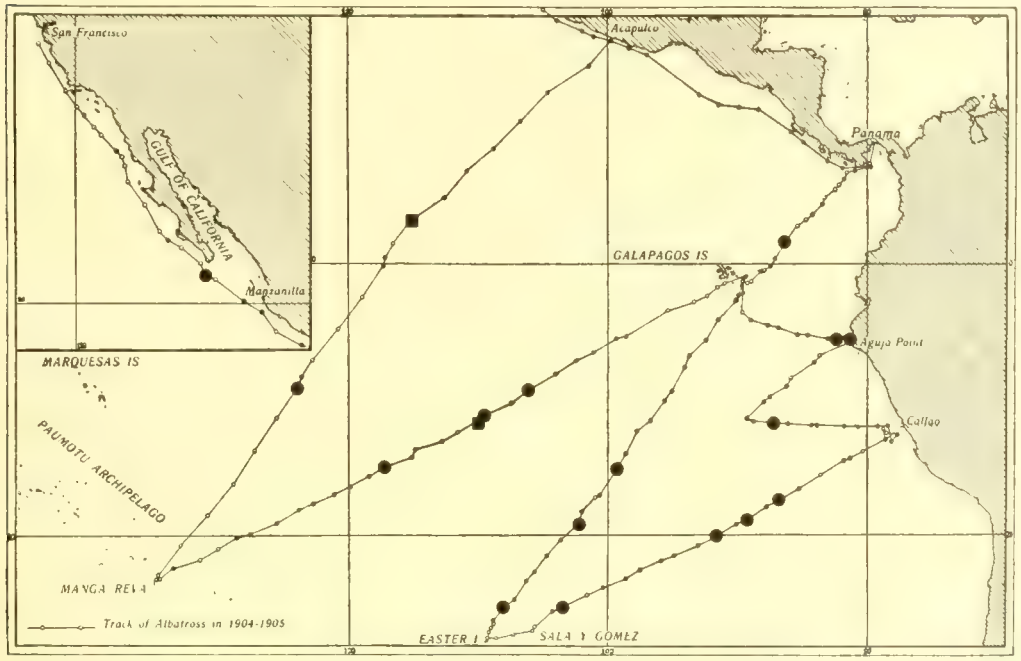

FIGURE 9.— Occurrence of *Phalacroma argus* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

sumably the most primitive. The following species are mentioned in this connection:— *P. operculatum* Stein *s. str.*, *P. ovum* Schütt, *P. operculoides* Schütt *s. str.* However, the degree of relationship between each of these simple species and *P. argus* is not known; in other words, which of them is more closely related to this species than the others. *Phalacroma argus* is readily distinguished from these species by the shape and structure of its sulcal lists. See also p. 113.

Occurrence: — *Phalacroma argus* is recorded at eighteen of the 127 stations. There are 1, 4, 4, 3, 4, and 2 stations on the six lines of the Expedition. Of these eighteen stations, one (4583) is in the California Current; one (4637) in the Panamic Area; three (4652, 4655, 4664) in the Peruvian Current; two (4691,

4695) in the Easter Island Eddy; ten (4679, 4681, 4683, 4701, 4705, 4722, 4724, 4725, 4730, 4740) in the South Equatorial Drift; one (4540) in the South Equatorial Current. At two stations (4725 [Salpa], 4540), the species was taken at the surface; at one station (4652) in a haul from 100–0 fathoms, and at one station (4701) in a haul from 800–0 fathoms as well as in a haul from 300–0 fathoms. All the other records refer to catches from 300–0 fathoms only.

The temperature range of these eighteen stations at the surface was 65°–83°; and the average was 73.7°. At Stations 4725 and 4540, where the species was taken at the surface, the surface temperature was 77° and 79°, respectively.

At one station (4681) the frequency is 2%; at two stations (4655, 4691) it is 1%; at the remaining stations it is less than 1%.

The species was first recorded by Stein (1883) "aus dem Atlantischen Meer und der Südsee." Hensen (1911) found it at a very great number of stations throughout the tropical, subtropical, and warm-temperate regions of the Atlantic. "*P. argus* tritt schon im Floridastrom auf, ist im westlichen Teil der Sargossosee gut vertreten und kommt sonst ziemlich gleichmässig, aber lückenhaft vor" (Hensen, 1911, p. 167). The specimens drawn by Schütt (1895) were probably taken either in the tropical, subtropical, or warm-temperate regions of the Atlantic or in the Gulf of Naples. Jörgensen (1923, p. 13, 14), who states that this species is "known from many places in the warmer Atlantic, including the Florida Current," reports it from the Bay of Cadiz; Pavillard (1909, 1916) from the Gulf of Lyons; Entz (1902b, 1905) from the Adriatic Sea; Jörgensen (1923) from "throughout the whole of the Mediterranean (at fourteen out of thirty-seven stations), everywhere in single specimens." In the Red Sea it has been found by Schröder (1906a); in the Gulf of Aden by Ostenfeld and Schmidt (1901); in the Arabian Sea by Ostenfeld and Schmidt (1901), Cleve (1901a), and Schröder (1906a); in the Indian Ocean by Cleve (1901a) and Karsten (1907). Ostenfeld and Schmidt (1901) found it in surface waters and at a depth of twenty feet; Karsten (1907) in a catch from 100 meters. Most of the remaining records mentioned in this paragraph probably refer to surface catches.

Ostenfeld and Schmidt (1901) found the species in waters of 79.5° and 82.4°.

Only Stein (1883) and Jörgensen (1923) give drawings by means of which the accuracy of their determinations may be judged.

This is a eupelagic species occurring in tropical, subtropical, and warm-temperate regions of all seas. The Expedition records reveal an almost even distribution throughout the area investigated, with an optimum habitat in deeper rather than surface waters, within the levels of photosynthesis.

Phalacroma apicatum, sp. nov.

Figure 10

Phalacroma sp. Okamura, 1907, p. 134, pl. 4, fig. 26a and b.

Diagnosis: — Body irregularly obovate or sublozenge-shaped in lateral outline, with subconical epitheca; deepest at or just behind girdle; length: depth, 1.24–1.30: 1; longitudinal axis deflected posteroventrally at 0°–10°. In ventral view subbiconical, with rounded apices, widest at girdle, 1.40 times longer than wide. Posterior cingular list 0.49–0.53 the length of body from apex. Lists resemble those of *Phalacroma argus*. Of the main ribs of left sulcal list R_2 is

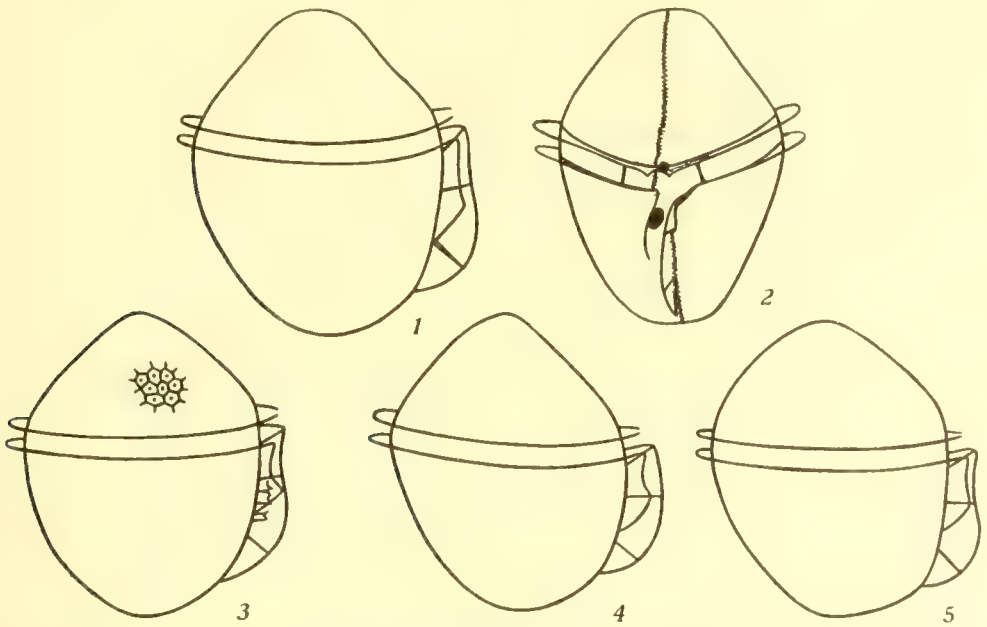

Figure 10.— *Phalacroma apicatum*, sp. nov. 1, 3, 4, 5, in right lateral view; 2, in ventral view. Left sulcal list with traces of reticulation in specimen represented by 3; surface markings indicated only on small portion of theca in 3. × 430. 1, 2, from type specimen, Station 4737 (300–0 fathoms); 3, from Station 4730 (300–0 fathoms); 4, from Station 4737 (300–0 fathoms); 5, from Station 4734 (300–0 fathoms).

0.09–0.17 and R_3 is 0.12–0.17 the greatest depth of body. Surface markings of theca as in *P. argus;* sometimes apparently absent. Length, 91.8–102.2 μ.

Tropical and subtropical Pacific.

Description: — A rather large species with the body irregularly obovate or sublozenge-shaped in lateral outline, with subconical epitheca, deepest at or just behind the girdle, and 1.27 (1.24–1.30) times longer than deep. The longitudinal axis of the body is either perpendicular to the transverse furrow (Figure 10: 3), or it is deflected posteroventrally at an angle of 1°–10°.

The epitheca is subconical, about as deep as the hypotheca, the ratio being 0.99 (0.95–1.00): 1, highest in or just dorsally to the center and very prominent above the anterior cingular list; it has gently convex, almost straight or even slightly concave side contours, which are nearly perpendicular to each other, and rounded apex. The transverse furrow is flat or somewhat convex; and its width is 0.16 (0.14–0.19) the greatest height of the epitheca. The posterior cingular list is 0.50 (0.49–0.53) the length of the body from the apex. The hypotheca is sometimes almost symmetrical (Figure 10: 3), but in most specimens it has a more or less pronounced posteroventral inclination (see above). It is somewhat irregularly, seldom regularly, ovoidal. The dorsal margin is evenly and gently convex. The ventral margin sometimes has about the same curvature as the dorsal, but in nearly all the specimens it is somewhat more strongly curved; in some, however, (Figure 10: 5) it forms a broadly rounded corner at the posterior end of the left sulcal list, in which case its anterior portion is but slightly convex. The posterior end of the body is broadly convex and always distinctly broader than the anterior. In ventral view (Figure 10: 2) the body is subbiconical, about 1.40 times longer than wide and widest at the transverse furrow; the side contours of the epitheca and of the hypotheca are slightly convex or almost straight; and the anterior and posterior ends are rounded, the anterior slightly narrower than the posterior.

The cingular lists are as in *Phalacroma argus*. The sulcus is about half as long as the hypotheca. The flagellar pore is about a girdle-width behind the junction of the cingulum and the sulcus. On the ventral side of the left valve a small pore is found near the sagittal suture, just in front of the anterior cingular list. The right sulcal list resembles that of *P. argus*, but it sometimes (Figure 10: 1) extends to the posterior main rib of the left sulcal list. The left sulcal list also resembles that of *P. argus* but is, on the average, somewhat wider. The ratios between the main ribs of this list and the greatest depth of the body are as follows: — anterior main rib, 0.13 (0.10–0.15): 1; fission rib, 0.12 (0.09–0.17): 1; posterior main rib, 0.14 (0.12–0.17): 1. Sometimes (Figure 10: 3) this list has a faint and irregular reticulation; and in some specimens its free margin is evenly convex throughout the whole length (Figure 10: 4). The distance between the anterior main rib and the fission rib is 0.40 (0.33–0.50) the distance from the anterior to the posterior main rib. The posterior main rib has a posterior inclination of 42° (30°–50°). There are no accessory lists or sails.

The surface markings of the thecal wall are the same as in *Phalacroma argus;* sometimes the reticulation seems to be absent.

Megacytic stages have not been seen.

The proportions of five of the Expedition specimens and of that drawn by Okamura (1907, fig. 26b) were measured.

Dimensions: — Expedition specimens: Length of body, 91.8–102.2 μ (average, 96.2 μ; type, 101.5 μ). Greatest depth of body, 71.5–81.3 μ (average, 75.5 μ; type, 77.8 μ). Okamura's (1907, fig. 26b) specimen: Length of body, 101 μ. Greatest depth of body, 76 μ.

Variations: — This species is rather variable in the inclination of the longitudinal axis of the body, in the shape and relative height of the epitheca and of the hypotheca, in the shape of the right sulcal list, in the shape and structure of the left sulcal list, and in the surface markings of the thecal wall. The variations in the inclination of the longitudinal axis of the body and in the shape of the body probably are partly apparent and due to the tilting of some of the specimens examined. The epitheca generally is pronouncedly subconical, but sometimes specimens are found which in the shape of the epitheca approach, more or less, *Phalacroma argus* (Figure 10: 5). The ventral margin of the left sulcal list is gently sigmoid in most specimens; in exceptional cases it is evenly convex (Figure 10: 4).

Comparisons: — The structurally nearest species to *Phalacroma apicatum* is *P. argus*, from which it differs in its more contracted epitheca. For further discussion, see p. 107.

Phalacroma circumcinctum, which shows a rather striking resemblance to *P. apicatum* in the shape of the body, especially in dorsoventral view, differs in having the longitudinal axis of the body deflected posterodorsally, in having a parasagittal list, in the shape and structure of the sulcal lists, and in the surface markings of the thecal wall. The question as to whether or not these two species are closely related must be left open.

The distinguishing characteristic of *Phalacroma apicatum*, when compared with *P. argus*, *i.e.*, the subconical shape of the epitheca, is found also in *P. operculatum* Stein *s. str.* (Stein, 1883, pl. 18, fig. 8), in one of the two specimens figured by Schütt (1895, pl. 3, fig. 17: 2) under the name of *P. vastum* var. *acuta*, in the rather highly differentiated *P. turbineum* (Plate **2**, fig. 3) and in *P. reticulatum* (Plate **4**, fig. 3). In the case of *P. operculatum* and *P. vastum* var. *acuta* (= *P. acutum* Pavillard), this similarity may be considered a sign of close relationship, *i.e.*, as an expression of an inherent "tendency." On the other hand, the relationships of *P. turbineum* and *P. reticulatum* to *P. apicatum* are uncertain. See also p. 191.

Synonymy: — Okamura (1907, p. 134, fig. 26) suggested that his *Phalacroma* sp. might represent *P. porodictyum* Stein. According to the size and the magnification of the drawing, this specimen was 101 μ long.

Occurrence: — *Phalacroma apicatum* is recorded at five of the 127 stations. There are 0, 0, 0, 1, 4, and 0 stations on the six lines of the Expedition. Of these five stations one (4697) is in the Easter Island Eddy, and four (4730, 4732, 4734, 4737, type locality) are in the South Equatorial Drift. All the records refer to hauls from 300–0 fathoms.

The temperature range of these five stations at the surface was 75.0°–81.5°; the average was 79.1°.

The frequency in every case is less than 1%.

The species, which previously was known from Japanese waters, is probably eupelagic and widely distributed in tropical and subtropical seas. In the material of the Expedition it is limited to the Easter Island Eddy and the western portion of the South Equatorial Drift; in other words, it has about the same distribution as *Amphisolenia schauinslandi* and *A. thrinax* and several other warm-water forms. Its average temperature is exceptionally high, 79.1°.

Phalacroma circumcinctum Kofoid and Michener

Plate 1, fig. 4, 5. Figure 8: 3

Phalacroma circumcincta Kofoid & Michener, 1911, p. 288, 291.

Diagnosis: — Body subovate in lateral view, deepest at girdle; length: depth, 1.25: 1; epitheca with slight ventral inclination, hypotheca almost symmetrical. In ventral view subbiconical, 1.54 times longer than wide, widest at girdle, with narrowly rounded apices. Posterior cingular list 0.46 the length of body from apex. Cingular lists without ribs. Right sulcal list reticulate. Left sulcal list: distance between posterior cingular list and R_3 is 0.38 the length of body; R_2 is 0.07 and R_3 is 0.15 the greatest depth of body; at R_3 margin forms rounded corner at 90°; R_1 is absent; R_2 is T-shaped; R_3 inclined posteriorly at 80°–85°. On right valve of epitheca and hypotheca there is an apparently structureless parasagittal list forming a direct continuation of left sulcal list; its maximum width but slightly exceeds half the width of transverse furrow. Theca densely areolate; 30–35 areoles border girdle posteriorly. Length 86.5 μ.

Eastern subtropical Pacific.

Description: — A medium-sized species, with body subovate in lateral outline, deepest at the girdle, and about 1.25 times longer than deep. The longi-

tudinal axis of the body is deflected anteroventrally at an angle of about 2°, due to the ventral inclination of the epitheca.

The epitheca is about as deep as the hypotheca and very prominent above the anterior cingular list; it is inclined slightly ventrally; in other words, it is highest slightly ventrally to the center. Its ventral, anterior, and dorsal margins are confluent; the ventral and anterior are rather strongly convex; the dorsal is gently convex, somewhat flattened. The transverse furrow is slightly concave, and its width is about 0.26 the greatest height of the epitheca. The posterior cingular list is about 0.46 the length of the body from the apex. The hypotheca is almost symmetrical; its ventral, posterior, and dorsal margins are confluent; the posterior margin is somewhat more strongly convex than the ventral and the dorsal. The posterior end of the body is somewhat narrower than the anterior. In dorsoventral view the body is subbiconical, widest at the girdle, and about 1.54 times longer than wide; the side contours of the epitheca and of the hypotheca are gently concave or almost straight; the anterior and posterior ends of the body are narrowly rounded or subtruncate, and of about the same width.

The cingular lists are subhorizontal and subequal; their width about equals the width of the transverse furrow; and they appear to lack ribs. The sulcus is about half as long as the hypotheca. The flagellar pore is about a girdle-width behind the junction of the cingulum and the sulcus. On the ventral side of the left valve a small pore is found a short distance from the sagittal suture and just in front of the anterior cingular list. The right sulcal list extends to a point somewhat behind the fission rib of the left sulcal list; even in the widest region its ventral margin does not extend to the ventral margin of the left sulcal list; it is of almost equal width throughout the greater portion of its length; its free margin is gently sigmoid, being concave anteriorly and convex posteriorly. The whole list is reticulated, with two longitudinal rows of meshes, 6–8 meshes in each row. The left sulcal list is comparatively long and narrow; the distance from the posterior cingular list to the posterior main rib is 0.38 the length of the body; at the place of the anterior main rib the width of the list is about 0.10 the greatest depth of the body; the fission rib is about 0.07, the posterior main rib about 0.15 the greatest depth of the body; behind the posterior main rib the list decreases suddenly in width. The ventral margin of this list is gently sigmoid, being concave anteriorly and convex posteriorly; at the posterior main rib the margin forms a rounded corner at an angle of about 90°. The posterior margin of this list is almost straight. The anterior main rib of this list was not developed in the type specimen. The fission rib is T-shaped, being divided distally into two

branches which form a marginal rib along the anterior half of the list. The posterior main rib is gently concave posteriorly and not club-shaped; it has a posterior inclination of about 80°–85°. The distance from the posterior cingular list to the fission rib is about 0.33 the distance between the posterior cingular list and the posterior main rib. With the exception of the main ribs, the left sulcal list appears to lack structural differentiation. On the right valve there is an apparently structureless parasagittal list. This list extends from the left sulcal list, of which it is a direct continuation, to the girdle, and along the anterior and ventral margins of the epitheca. On the epitheca the width of this list is somewhat more than half the width of the transverse furrow; on the hypotheca the maximum width about equals half the width of the transverse furrow.

The thecal wall is areolate, and the areoles are of almost uniform size and evenly distributed. There are from thirty to thirty-five areoles on each valve bordering the posterior margin of the girdle. In the transverse furrow there are three irregular rows of areoles.

Megacytic stages have not been seen.

The proportions of the type were measured.

Dimensions: — Length of body, 86.5 μ. Greatest depth of body, 68.9 μ.

Comparisons: — The above description is made from the original drawings of the type specimen. The long, irregular, hyaline appendage of this specimen (Plate 1, fig. 5), apparently issuing from the sagittal suture near the posterior main rib of the left sulcal list, is of unknown nature and significance. Presumably it is a temporary structure, and it may be connected with reorganizing processes either independent of, or following binary fission; compare Kofoid (1908). This structure has not been considered of any systematic importance and thus has been omitted from the description of the species and disregarded in the discussion of the relationships of this form. The shape and the lack of structure of the parasagittal list also appear to indicate that this specimen was taken while still in a process of skeletal reorganization (see Plate 3, fig. 4).

This species has a somewhat uncertain position within the genus. It resembles *P. apicatum* in the somewhat elongate and, in dorsoventral view, subbiconical shape of its body. Other features in which these two species agree are the subequatorial position of the girdle and the width and inclination of the cingular list; however, since these species presumably are relatively primitive in these respects, these similarities are of less importance in this connection. *P. circumcinctum* is easily distinguished from *P. apicatum* by the following characters: — (*1*) the epitheca is inclined ventrally instead of dorsally; (*2*) the right

sulcal list is reticulate, and its free margin is gently sigmoid and not angular; (*3*) the margin of the left sulcal list is angular at the posterior main rib; (*4*) the theca is areolate and not reticulate; (*5*) on the right valve of the epitheca as well as of the hypotheca there is a well-developed parasagittal list. The differences between these two species, therefore, appear to be more profound than the similarities. However, in spite of this, *P. circumcinctum* is probably rather closely related to *P. apicatum* and, preliminarily, should be placed in the ARGUS group. Most of the characters of *P. circumcinctum* which are different from those of *P. apicatum* either have maintained a comparatively primitive type or they are expressions of "tendencies" inherent in the ARGUS group but not developed morphologically in most of the members of this group. For example, the angularity of the margin of the left sulcal list and the areolation of the thecal wall in *P. circumcinctum* probably are relatively primitive features; they are found also in *P. porodictyum* which is closely related to *P. apicatum* and *P. argus*. A parasagittal list on the right valve also is characteristic of *P. blackmani*, which undoubtedly is a very close relative of *P. striatum* and thus also of *P. apicatum* and *P. argus* (see p. 107).

The T-shaped fission rib of the left sulcal list is a character that is known only in *Phalacroma circumcinctum* and *P. ovum*. These two species resemble each other also in the width, structure, and inclination of the cingular lists, in the size and shape of the right sulcal list, and in the surface markings of the theca; they differ in the relative height of the epitheca, in the shape of the epitheca and of the hypotheca in dorsoventral view, in the relative length and the inclination of the posterior main rib of the left sulcal list, and in the presence or absence of a parasagittal list.

It also should be noted in this connection that *Phalacroma circumcinctum* resembles *P. limbatum* in the subequatorial position of the girdle, in having a parasagittal list on the right valve of both the epitheca and the hypotheca, in the subbiconical shape of the body in dorsoventral view, and in the structure of the sulcus and of the adjacent regions (compare Plate 1, fig. 4, and Plate 3, fig. 3). *Phalacroma limbatum* is easily distinguished from *P. circumcinctum* in the subcircular shape of its body in lateral view, in the high structural differentiation of its right parasagittal list, in having two parasagittal lists, in the size and shape of its left sulcal list, in the structure of its theca, and in the narrowness of its body in dorsoventral view.

Occurrence: — *Phalacroma circumcinctum* is recorded at only one (4671) of the 127 stations, on the second line of the Expedition and in the Peruvian Cur-

rent, from 300–0 fathoms, in a surface temperature of 66°, with a frequency of less than 1% (one specimen).

Phalacroma ovum Schütt

Figure 11

Phalacroma ovum Schütt, 1895, p. 90.

?*Phalacroma operculatum* Stein, 1883, *partim*, pl. 18, fig. 7. ?Forti, 1922, *partim*, p. 105, 190, 208, pl. 7, fig. 111. *non* Schütt, 1895, p. 93, pl. 2, fig. 10: 1–3. *non* Jörgensen, 1923, p. 9, 10, fig. 7.

Phalacroma operculoides Schütt, 1895, *partim*, pl. 2, fig. 11: 2. Okamura, 1912, p. 18, fig. 81, 82. Jörgensen, 1923, p. 8, 9, 45, fig. 5. *non* Cleve, 1899c, p. 40. *non* Lohmann, 1902, p. 53. *non* Forti, 1922, p. 106, 190, 208, pl. 7, fig. 111.

Diagnosis: — Body obovate in lateral outline, deepest at or somewhat behind girdle; length: depth, 1.20–1.31: 1; longitudinal axis deflected posteroventrally at 0°–4°. In dorsal view narrowly obovate, 1.59–1.64 times longer than wide. Posterior cingular list 0.28–0.36 the length of body from apex. Cingular lists probably without ribs. Left sulcal list 0.43–0.53 the length of body; distance between R_1 and R_3 is 0.33–0.37 the length of body; R_1 is 0.10–0.13, R_3 is 0.30–0.37 the greatest depth of body; margin forms angle of 60°–90° at R_3; R_2 is T-shaped; R_3 usually club-shaped and inclined posteriorly at about 30°. Theca finely and closely areolate. Length, 58.2–76.1 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is obovate in lateral view, deepest at, or, in most specimens, somewhat behind the girdle, and about 1.26 (1.20–1.31) times longer than deep. The longitudinal axis of the body either is perpendicular to the girdle, or it is slightly (1°–4°) deflected posteroventrally.

The epitheca is 0.93 (0.91–0.96) as deep as the hypotheca, and moderately elevated or very prominent above the anterior cingular list; sometimes (Figure 11: 1) it is strongly and evenly convex, dome-shaped, sometimes (Figure 11: 3, 2) of moderate convexity or rather flat; in most cases it is highest in the center, but in some specimens (Figure 11: 6) somewhat dorsally to the center. The transverse furrow is flat or slightly convex, and its width is 0.37 (0.26–0.42) the greatest height of the epitheca. The posterior cingular list is 0.32 (0.28–0.36) the length of the body from the apex. The hypotheca sometimes is symmetrical, sometimes it has a slight posteroventral inclination (see above); sometimes (Figure 11: 4) it is of an oval wedge shape, with rather flat dorsal and ventral margins; sometimes (Figure 11: 1) it is regularly oval, with well or moderately rounded dorsal and ventral margins; its posterior margin is strongly convex and confluent with the dorsal and ventral margins. The posterior portion of the

body is strikingly narrower than the anterior. In dorsoventral view the body is narrowly and regularly obovate, 1.59–1.64 times longer than wide, and widest at the girdle.

The cingular lists are subhorizontal, subequal, and about as wide as the transverse furrow; they appear to be without structural differentiation. The right sulcal list extends to a point midway between the fission rib and the posterior main rib of the left sulcal list, or it is slightly longer or shorter; in some specimens it is subtriangular, decreasing gradually in width posteriorly; in others it is subequal in width throughout its anterior half or even throughout the greater

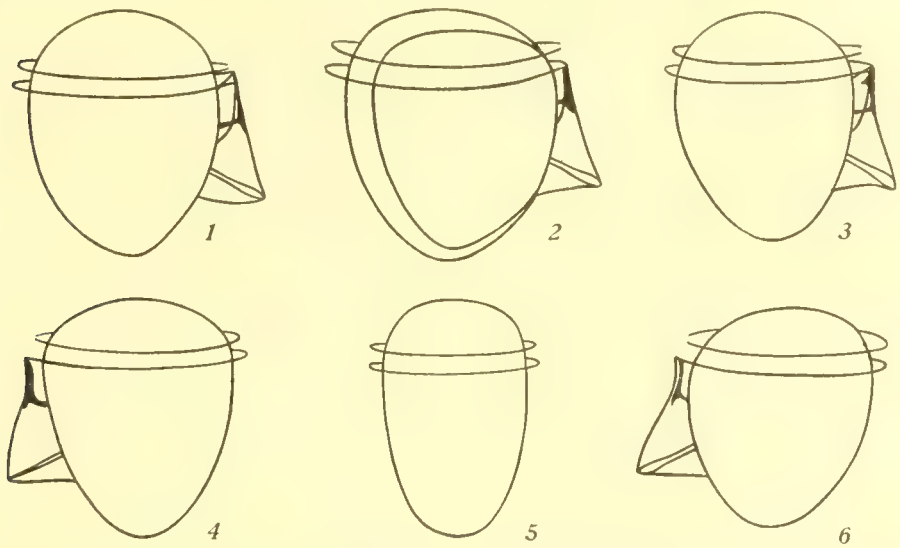

FIGURE 11.— *Phalacroma ovum* Schütt. 1, 2, 3, in right lateral view; 4, 6, in left lateral view; 5, in dorsal view. 2, from a megacytic specimen; surface markings omitted. × 430. 1, from Station 4737 (300–0 fathoms); 2, from Station 4709 (300–0 fathoms); 3, from Station 4721 (300–0 fathoms); 4, 5, from Station 4681 (300–0 fathoms); 6, from Station 4709 (300–0 fathoms).

portion of its length; anteriorly it is about as wide as the transverse furrow. The left sulcal list is of moderate length, narrow anteriorly and wide posteriorly. Its length is 0.50 (0.43–0.53) the length of the body, and the distance between the anterior and posterior main ribs is 0.35 (0.33–0.37) the length of the body. The anterior main rib, when present, is 0.12 (0.10–0.14), the fission rib 0.12 (0.10–0.13), and the posterior main rib 0.33 (0.30–0.37) the greatest depth of the body. Behind the last-mentioned rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list sometimes is almost straight or gently concave, sometimes it is gently sigmoid, concave anteriorly and convex posteriorly; at the posterior main rib it forms an angle of 75° (60°–90°); behind the last-mentioned rib it is almost straight, or gently concave

or convex. The fission rib is T-shaped, being divided distally into two branches, which form a marginal rib along the anterior third or half of the list; this marginal rib is sometimes more or less irregular. The posterior main rib is straight, or but slightly concave posteriorly, and in most cases somewhat club-shaped distally; it has a posterior inclination of 30° (25°–32°). Sometimes this list appears to have a faint reticulation (Stein, 1883, pl. 18, fig. 7). There are no accessory lists or sails.

The thecal wall is finely and closely areolate and has scattered pores; the areoles are of about the same size as the pores (Jörgensen, 1923, fig. 5).

Megacytic stages have been seen (Figure 11: 2). Sometimes the megacytic specimen has the transdiameter subequal to the length of the body.

The proportions of six Expedition specimens, and of the specimens figured by Schütt (1895) and Jörgensen (1923) were measured.

Dimensions: — Expedition specimens: Length of body, 66.9–76.1 μ (average, 71.4 μ). Greatest depth of body, 55.0–58.9 μ (average, 56.9 μ). The type specimen as figured by Schütt (1895, pl. 2, fig. 11: 2) was 61 μ long and 46 μ deep; Jörgensen's (1923), 60–66 μ long. According to the given magnifications, the specimens figured by Okamura (1912, pl. 5, fig. 81, 82) were about 58 μ and 34 μ long, respectively (see p. 120).

Variations: — Judging by the available figures, this species appears to be rather constant. The most variable features are the size of the body, the relative height and the shape of the epitheca, and the shape of the two posterior main ribs of the left sulcal list. With regard to the porulation of the theca, see *Phalacroma operculoides* and *P. operculatum* Jörgensen (1923, p. 8, 9).

Comparisons: — Most of the Expedition specimens agree closely with the type specimen as figured by Schütt (1895, pl. 2, fig. 11: 2). They differ in having the fission rib of the left sulcal list T-shaped and the posterior main rib of this list club-shaped. It should be mentioned, however, that in some of these specimens the last-mentioned rib was not club-shaped.

The specimen figured by Jörgensen (1923, fig. 5) under the name of *Phalacroma operculoides* shows also a close agreement with the type. Those figured by Okamura (1912, pl. 5, fig. 81, 82) are comparatively small; according to the magnifications given, they are only 58 μ and 34 μ long, respectively. The last measurement may be erroneous, and due to a mistake in the magnification; it has been disregarded in the diagnosis.

Judging by the simplicity of its structure, *Phalacroma ovum* probably is fairly closely related to the comparatively primitive members of this genus, *e.g.*,

P. porodictyum Stein, *P. operculoides* Schütt *s. str.*, *P. operculatum* (Stein) Jörgensen, and *P. argus* Stein. Due to the simplicity of their organization, the interrelationships of these species are very difficult to establish. However, it seems rather plausible that *P. ovum* is more closely related to *P. porodictyum* than to any other known species. *Phalacroma ovum* is most easily distinguished from all these species by the shape and structure of its left sulcal list.

Phalacroma circumcinctum, which differs very strikingly from *P. ovum* in the subequatorial position of its girdle, has the fission rib of the left sulcal list T-shaped in the same way as the last species.

Judging by the great similarities in the size and shape of the body and in the shape and structure of the left sulcal list, *Phalacroma ovum* and *P. doryphorum* probably are rather closely related. The last species differs strikingly from the first in having a large, triangular posterior sail.

Synonymy: — The synonymy of this species is complicated to such an extent that it is difficult, if not impossible, to unravel it. Stein (1883, pl. 18, fig. 7–10) figures, under the name of *Phalacroma operculatum*, two forms which probably are specifically distinct. Jörgensen (1923, p. 9), the first to point out this fact, applies the name *operculatum* to the specimen represented by Stein (pl. 18, fig. 8). This specimen therefore becomes the type of a species which should be named *P. operculatum* (Stein) Jörgensen. The specimens represented by Stein (pl. 18, fig. 7, 9, 10) are assigned by Jörgensen (1923, p. 9) to *P. porodictyum* Stein. However, on account of the almost complete agreement between the specimen represented by Figure 11: 1 and Stein's Plate 18, fig. 7, with regard to the shape of the body and the position of the girdle, it seems more plausible that these specimens of Stein belong to the species described and figured above under the name of *P. ovum* Schütt. The uncertainty of the assignment is mainly due to the fact that the left sulcal list is incomplete (damaged ?) in Stein's Plate 18, fig. 7. The lack of porulation in the last figure probably is due to an omission; see Jörgensen (1923, p. 9). If our identification is correct, Stein (1883, pl. 18, fig. 7, 9, 10) was the first to figure a specimen of *P. ovum*, and *P. operculatum* Stein, *partim*, is a synonym of *P. ovum* Schütt.

Phalacroma operculatum Stein is used by Daday (1888, p. 99; *Phalarocoma operculatum, lapsu pennae*), Schütt (1895, p. 93, pl. 2, fig. 10), Hensen (1895, p. 190; 1911, p. 137, 138, 166, 167, 393, tab. 15), Lemmermann (1899, p. 371; 1901a, p. 373; 1905a, p. 35), Murray & Whitting (1899, p. 330, tab. 1, 2, 3, 4, 5, 6, 7, 8, 9), Schröder (1900a, p. 9, 11, 19; 1906a, p. 321, 327, 330; 1911, p. 17, 37), Rauschenplat (1900, p. 134), Cleve (1901a, p. 17; 1901c, p. 272; 1902b, p. 37; 1903b, p. 347), Lohmann (1902, p. 53; 1920, p. 485, 492, 496, 504, 505, 507, 509, 511, 513, 515, 517, 524, 525, 529, 532, 536, 537, 544, 551, 554, 561, 572, 574, 585, 596), Entz (1902b, p. 94; 1904, p. 14; 1905, p. 111), Pavillard (1905, p. 59, 81, 102; 1909, p. 283; 1916, p. 44, 47, 48, 49, 50, 54), Zacharias (1906, p. 509, 530, 534, 536, 544, 557), Karsten (1907, p. 236, 247, 263, 304, 349, 355, 359), Nathansohn (1908, p. 60; 1909, p. 42), Stüwe (1909, p. 237, 252, 287), Schiller (1912, p. 27), Forti (1922, p. 105, 190, 208, pl. 7, fig. 110, 112; fig. 112 is erroneously called *P. porodictyum*, and the figure representing the last species has no number), Jörgensen (1923, p. 9, 10, fig. 7), and Lindemann (1924, p. 10). Most of the investigators mentioned in this paragraph do not give any information as to which of the two forms figured by Stein (1883) under the name of *P. operculatum* they refer to. Daday, Hensen, Lemmermann, Murray and Whitting, Schröder, Rauschenplat, Cleve, Lohmann, Entz, Pavillard, Zacharias, Karsten, Nathansohn, Stüwe, Schiller, and Lindemann have not been included in the bibliographical list of *P. ovum*. The remaining ones give figures by means of which their determinations can be checked. Forti (1922) refers to both the forms figured by Stein (1883) under the name of *P. operculatum*.

According to Jörgensen (1923, p. 8) "two apparently different species" are figured by Schütt (1895, pl. 2, fig. 11: 1–3) under the name of *Phalacroma operculoides*. Jörgensen applies the name *operculoides* to the specimen represented by Schütt (1895, pl. 2, fig. 11: 2); the second figure was chosen because "unfortunately, his [Schütt's] first figure is uncertain, and seems to represent the same species which he notes, lower down on the same plate, as *Phalacroma porodictyum* var. *parvulum*, while the second figure shows a characteristic species closely related to the foregoing [*P. porodictyum*], and possibly merging into the

same" (Jörgensen, 1923, p. 8). It seems almost unquestionable that the specimens represented by Schütt (1895, pl. 2, fig. 11: 1–3) belong to two specifically distinct forms. However, it is necessary to reject Jörgensen's decision as to the nomenclature of these two forms, since Schütt (1895, p. 90) refers to his Plate 2, fig. 11: 2 as *P. ovum;* on the other hand, except in the explanation of the plates, Schütt never refers to this figure as representing *P. operculoides.* The name *P. operculoides* therefore should be used for the species represented by Schütt (1895, pl. 2, fig. 11: 1, 3), while the name *P. ovum* should be applied to the species represented by Plate 2, fig. 11: 2.

Phalacroma operculoides Schütt has been used by several authors, viz., Cleve (1899c, p. 40), Lemmermann (1899, p. 372; 1901a, p. 373; 1905a, p. 35), Lohmann (1902, p. 53), Stüwe (1909, p. 252, 287), Okamura (1912, p. 18, fig. 81, 82), Pavillard (1916, p. 54; 1923a, p. 879), Forti (1922, p. 106, 190, 208, pl. 7, fig. 111), and Jörgensen (1923, p. 8, 9, 45, fig. 5). *P. operculoides* Cleve (1899c) refers to *P. rotundatum,* according to Cleve (1901c, p. 241); see also Paulsen (1908, p. 18). Lemmermann only refers to data given by other writers. The specimens referred by Lohmann (1902, p. 53) to *P. operculoides* were only 35 μ long, which indicates that they are referable to *P. operculoides s. str.* Stüwe (1909) and Pavillard (1916, 1923a) do not give any information as to which of the two forms figured by Schütt (1895) under the name of *P. operculoides* they refer to. Under these circumstances these authors are not included in the bibliography of *P. ovum.* Forti (1922) refers to Schütt (1895, pl. 2, fig. 11: 1), not to *P. ovum. P. operculoides* Okamura (1912) and Jörgensen (1923) refer to *P. ovum* (see p. 120).

Occurrence: — *Phalacroma ovum* is recorded at ten of the 127 stations. There are 2, 1, 1, 2, 4, and 0 stations on the six lines of the Expedition. Of these ten stations, one (4587) is in the Mexican Current; one (4617) in the Panamic Area; one (4657) in the Peruvian Current; and seven (4681, 4709, 4711, 4721, 4724, 4730, 4737) in the South Equatorial Drift. At one station (4724) the species was taken in a haul from 800–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms.

The temperature range of these ten stations at the surface was 68°–82°; the average temperature was 75.8°.

At one station (4657) the frequency is 1%, at the remaining stations it is less.

Schütt (1895) did not give any information as to the localities of his specimens; however, his material probably was taken either at Naples, or in the tropical or subtropical regions of the Atlantic. Jörgensen (1923) found this species "fairly common" in the Mediterranean, and "most frequent in the inner parts" of this sea. Okamura (1912) recorded it from Japanese waters.

Judging by the numerous records which possibly may refer to *Phalacroma ovum* (see p. 121), this species appears to be eupelagic and widely distributed in tropical, subtropical, and warm-temperate seas. The ten record stations are distributed fairly evenly over the area investigated by the Expedition. The absence of surface records is noteworthy. The species probably has its optimum habitat in deeper waters within the levels of photosynthesis.

Phalacroma pyriforme, sp. nov.

Figure 4: 4, 5

Diagnosis: — Body obovate in lateral outline, deepest at girdle; length: depth, 1.13: 1. In dorsal view inverted pyriform, widest at girdle, broadly

rounded anteriorly, narrowly rounded posteriorly; hypotheca with concave side contours; length: width, 1.30: 1. Posterior cingular list 0.43 the length of body from apex. Cingular lists somewhat wider than transverse furrow. Left sulcal list relatively large; its length 0.56 the length of body; throughout its anterior half it is of uniform width, 0.25 the depth of body; posteriorly it decreases gradually in width; its free margin gently and evenly convex; structure unknown. Theca finely and closely areolate. Length, 48.2 μ.

Eastern tropical Pacific.

Description: — A small species, with the body obovate in lateral outline, deepest at the girdle. The ratio between the length and the depth is 1.13: 1. The longitudinal axis is about perpendicular to the girdle.

The epitheca is about as deep as the hypotheca, highest in the center, evenly and strongly convex, dome-shaped, and very prominent above the anterior cingular list. The transverse furrow is gently convex, and its width is 0.45 the greatest height of the epitheca. The posterior cingular list is about 0.43 the length of the body from the apex. The hypotheca is symmetrical; its dorsal and ventral margins are evenly and moderately convex and confluent with the posterior margin, which is strongly and evenly convex. The posterior portion of the body is strikingly narrower than the anterior. In dorsoventral view the body is inverted pyriform in outline, widest at the girdle, broadly rounded anteriorly, narrowly rounded posteriorly, and with the lateral contours of the hypotheca moderately concave; the ratio between the length and the width is 1.30: 1.

The cingular lists are subhorizontal, subequal, and somewhat wider than the transverse furrow; their structure is unknown. The right sulcal list is about half as long as the left; its anterior half is subuniform in width, and about half as wide as the transverse furrow; posteriorly it decreases gradually in width. The left sulcal list is relatively large; its length is about 0.56 the length of the body; throughout its anterior half it is of uniform width and about 0.25 the greatest depth of the body; posteriorly it decreases gradually in width; its free margin is gently and evenly convex; in other words, it is not angular posteriorly, as in most species of the genus; its structure is unknown. There are no accessory lists or sails.

The thecal wall is finely and closely areolate, about as in *Phalacroma doryphorum*. Pores have not been seen.

Megacytic stages were not recorded.

The proportions of the type were measured.

Dimensions: — Length of body, 48.2 μ. Greatest depth of body, 42.5 μ.

Comparisons: — *Phalacroma pyriforme* is established on two outline drawings made from a specimen found in the material of the Expedition.

The species appears to occupy a rather isolated position. The symmetry and small size of its body, and the fine and close areolation of its thecal wall are features that affiliate it with the relatively primitive members of the genus, *e.g.*, *Phalacroma parvulum*, *P. operculoides s. str.*, and *P. lens*. In the shape of its body in lateral view and in its relatively high epitheca, it resembles *P. argus*, *P. porodictyum*, *P. ovum*, and some other obovoidal species. The shape of its left sulcal list recalls *P. argus*, *P. apicatum*, and the species of the CUNEUS group. The pyriform shape of its body in dorsoventral view is unique but approaches the cuneate shape of the species of the CUNEUS and RAPA groups.

Occurrence: — This species is recorded at one of the 127 stations. This station (4713) is on the fourth line of the Expedition and in the Galapagos Eddy. The depth is 300–0 fathoms, the surface temperature 73°, and the frequency less than 1% (one specimen).

4. CUNEUS GROUP. *Phalacroma blackmani* is the only species of this group that is not included in the Expedition collections.

PHALACROMA CUNEUS Schütt

Figure 12, 13

Phalacroma cuneus SCHÜTT, 1895, p. 148, pl. 3, fig. 14; 1896, p. 27, fig. 38B. OSTENFELD, 1898a, p. 428. MURRAY & WHITTING, 1899, p. 330, tab. 4. LEMMERMANN, 1899a, p. 372; 1901a, p. 372. SCHRÖDER, 1900a, p. 19; 1906a, p. 322, 327, 330. CLEVE, 1901a, p. 16; 1901c, p. 270; 1902b, p. 35; 1903b, p. 347. OSTENFELD & SCHMIDT, 1901, p. 175. ZACHARIAS, 1906, p. 534. KOFOID, 1907a, p. 195. KARSTEN, 1907, p. 325, 353, 355. PAVILLARD, 1909, p. 283; 1915a, p. 2; 1916, p. 47, 49, 52. STÜWE, 1909, p. 287. OKAMURA, 1912, p. 18, pl. 5, fig. 76. JÖRGENSEN, 1923, p. 11, fig. 11.
Phalacroma cuneus STÜWE, 1909, p. 252 (*lapsus pennae*).
Phalacroma mitra OLTMANNS, 1922, *partim*, fig. 38: 1.

Diagnosis: —Body cuneate in lateral outline; epitheca very broadly rounded; posterior portion of hypotheca fairly broadly to rather narrowly rounded; deepest at posterior cingular list; length: depth, 0.92–1.09: 1; longitudinal axis deflected posteroventrally at 4°–5°. In dorsal view cuneate; posterior portion of hypotheca narrowly rounded to subacute; length: width, 1.22: 1. Posterior cingular list 0.23–0.28 the length of body from apex. Of the cingular lists the anterior is reticulated, the posterior is ribbed. Left sulcal list 0.50–0.67 the length of body; distance from R_1 to R_3 is 0.40–0.47 the length of body; R_2 is 0.09–0.11, and R_3 is 0.07–0.10 the greatest depth of body; widest somewhat in front of R_3; its ventral margin gently convex at R_3, seldom subangular; R_3 inclined posteriorly at 45°–

60°; irregularly and incompletely reticulate. Theca reticulate; twenty-five to thirty-five polygons border girdle posteriorly. Length, 72–88 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is cuneate in lateral outline, with a rather low and very broadly rounded epitheca, with the posterior portion of the hypotheca fairly broadly to rather narrowly rounded, with the greatest depth at the posterior cingular list, and about as deep as long. The ratio between the length and the depth of the body is 0.98 (0.92–1.09): 1. The longitudinal axis is deflected posteroventrally at an angle of 4°–5°.

The epitheca is about as deep as the hypotheca, very broadly and almost evenly convex, highest in or near the center, and moderately elevated above the anterior cingular list. The transverse furrow is flat to somewhat concave, and its width is 0.35–0.50 the greatest height of the epitheca. The posterior cingular list is 0.23–0.28 the length of the body from the apex. The hypotheca tapers posteriorly and is somewhat deflected posteroventrally (see above); its dorsal margin is almost straight or slightly convex to concave; its ventral margin is nearly straight or gently convex; its postmargin is evenly, and fairly broadly to rather narrowly convex, and confluent with the dorsal and ventral margins. In dorsoventral view the body is cuneate, with broadly rounded epitheca, and with the posterior portion of the hypotheca narrowly rounded to subacute; the side contours of the hypotheca are almost straight or slightly concave; the ratio between the length and the width is about 1.22: 1.

The cingular lists are subhorizontal, subequal, and about as wide as the transverse furrow. Along the base of the anterior cingular list, there is a series of ribs anastomosing into a row of polygons, which have about the same size and shape as the polygons in the transverse furrow; sometimes a more or less complete row of similar polygons is developed outside the basal row. The posterior cingular list has a great number of straight and simple ribs (Schütt, 1895, pl. 3, fig. 14: 2). The sulcus is about half as long as the hypotheca. The flagellar pore is about a girdle-width behind the junction of the cingulum and the sulcus. The right sulcal list is long and rather narrow; usually it ends at a point about half way between the fission rib and the posterior main rib of the left sulcal list, but sometimes it extends to the last-mentioned rib; anteriorly it is about as wide as or somewhat narrower than the transverse furrow, and posteriorly it tapers gradually. The left sulcal list is of moderate size. Its length is 0.50–0.67 the length of the body, and the distance between the anterior and posterior main ribs is 0.40–0.47 the length of the body. The anterior main rib, when present, is

about 0.07–0.09, the fission rib 0.09–0.11, and the posterior main rib 0.07–0.10 the greatest depth of the body. The greatest width of this list, which in most specimens is located somewhat in front of the posterior main rib, is about 0.12–0.20 the greatest depth of the body. In most specimens the free margin of this list is either gently sigmoid, concave anteriorly and convex posteriorly, or it is evenly to somewhat irregularly convex throughout; in other words, it is gently convex at the posterior main rib, and not angular as in most species of the genus. In exceptional cases (Figure 12: 2) this margin is slightly convex between the anterior and posterior main ribs, and subangular at and gently concave behind the posterior main rib. Posteriorly this list either tapers more or less suddenly, or it is more or less decurrent (Figure 12: 2). The main ribs of this list are straight and rather weak; none of them is club-shaped, but the posterior sometimes is rather wide. The distance between the anterior main rib and the fission rib is 0.28–0.35 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 45°–60°. Besides the main ribs, the left sulcal list has an irregular and incomplete reticulation. At least in some specimens (Jörgensen, 1923, fig. 11), there is a very narrow parasagittal list extending on the hypotheca from the left sulcal list to the posterior cingular list.

The thecal wall has a reticulum of medium-sized polygons, and each polygon has a small pore in the center. The polygons usually are about equal in size, and on each valve from twenty-five to thirty-five of them border the posterior margin of the girdle. In most specimens there are two rows of polygons in the transverse furrow, each row with twenty-five to thirty polygons on each valve; in other cases the two rows, partly or wholly, merge into a single row. Some of the polygons may be subdivided (Jörgensen, 1923, p. 12). From a point near the middle of the right sulcal list a spine-like process projects into the cytoplasm.

Megacytic stages of this species have been seen by Pavillard (1916) and are contained in the Albatross collection.

The dimensions of three specimens were measured.

Dimensions: — Expedition specimens: Length of body, 80–87 μ (average, 84 μ). Greatest depth of body, 77–95 μ (average, 86 μ). The largest of the specimens represented by Schütt (1895, pl. 3, fig. 14: 1) is about 88 μ long. The type specimen (Schütt, 1895, pl. 3, fig. 14: 3) is somewhat smaller, but its length cannot be determined, since it is figured in a tilted position. According to Jörgensen (1923, p. 11), the length is 72–88 μ.

Variations: — This species appears to be rather remarkably constant in shape and in structure. A fairly large number of specimens from Station 4664

were submitted to a careful examination; most of these agreed very closely with the specimen represented by Figure 12: 1. The size and the shape of the body and of the sulcal lists are the most variable characters. The body sometimes is longer than deep, and sometimes deeper than long; sometimes (Figure 12: 1) the posterior portion of the hypotheca is rather broad, sometimes (Figure 12: 2) it is rather narrow; the dorsal margin of the hypotheca may be straight, or gently convex to concave. Posteriorly the left sulcal list either tapers more or less suddenly (Figure 12: 1), or it is more or less decurrent (Figure 12: 2); its free margin

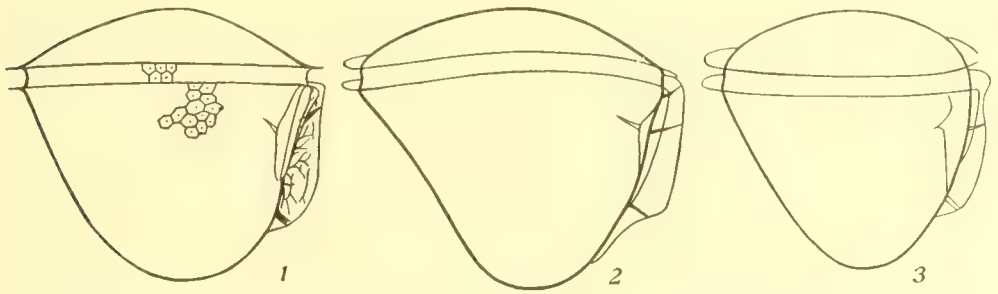

FIGURE 12.— *Phalacroma cuneus* Schütt, right lateral view. Structure of thecal wall and of left sulcal list indicated only in 1; 3 is somewhat tilted. × 430. 1, 3, from Station 4664 (300–0 fathoms); 2, from Station 4737 (300–0 fathoms).

usually is gently concave anteriorly and convex posteriorly, but it may be *vice versa*. The variations probably are partly apparent, and due to the tilting of some of the specimens examined.

Comparisons: — Schütt (1895) does not give any diagnosis or description of *Phalacroma cuneus*, and the specimens figured in lateral view by him are drawn in tilted positions. In spite of these discrepancies, the characteristics represented probably are sufficient for certainty of specific assignment. The Expedition specimens agree quite closely with those figured by Schütt (1895, pl. 3, fig. 14: 1–8).

Phalacroma cuneus is very closely related in structure to *P. blackmani*, *P. striatum*, and *P. giganteum*. They all agree in the following respects: — their epitheca is rather low and very broadly rounded; their hypotheca is more or less cuneate in lateral as well as in dorsoventral view; in lateral view the posterior portion of the hypotheca is fairly broadly to rather narrowly rounded, in dorsoventral view it is narrowly rounded or even acute. The free margin of their left sulcal list is gently convex at the posterior main rib, and not angular as in most species of this genus.

Without giving any reasons, Jörgensen (1923, p. 11) places *Phalacroma blackmani* as a synonym of *P. cuneus*. Is this justifiable? According to the

only drawing of this species available, *viz.*, that of the type specimen (Murray and Whitting, 1899, pl. 31, fig. 4), *P. blackmani* is about 125 μ long, has a parasagittal list which extends on the hypotheca from the left sulcal list to the posterior cingular list and is locally wider on the posterior portion of the hypotheca, and its left sulcal list lacks reticulation and has the main ribs concave anteriorly. *P. cuneus* has a maximum length of 88 μ, and its left sulcal list has an incomplete and irregular reticulation and straight main ribs. At least in some specimens (Jörgensen, 1923, fig. 11), *P. cuneus* has, just as *P. blackmani*, a parasagittal list extending on the hypotheca from the left sulcal list to the posterior cingular list, but this parasagittal list is very narrow throughout its whole length. Schröder (1906a, p. 330), Karsten (1907, p. 262, 473), and Stüwe (1909, p. 238), who have recorded *P. blackmani*, found also *P. cuneus* in the material examined by them. In short, according to the available descriptions and figures differences do exist between *P. cuneus* and *P. blackmani* which appear to be of specific nature, and some investigators have separated the two forms. Until further data are available, these two forms should be considered specifically distinct.

Phalacroma cuneus differs from *P. striatum* in its smaller size (72–88 μ, as compared with 102–136 μ) and its less developed left sulcal list. From *P. giganteum* it is easily distinguished by its smaller size (72–88 μ, as compared with 148 μ). For further discussion about the relationships of these species, see p. 133.

Synonymy: — The presence of a parasagittal list in the specimens determined as *P. cuneus* by Jörgensen (1923) calls for a reëxamination of this species to determine the prevalence of this structure which was not observed by Schütt (1895) or by us.

Occurrence: — *Phalacroma cuneus* is recorded at sixty-three of the 127 stations. There are 9, 19, 7, 10, 11, and 7 stations on the six lines of the Expedition. Of these sixty-three stations, one (4583) is in the California Current; six (4587, 4590, 4594, 4598, 4605, 4545) in the Mexican Current; six (4609, 4613, 4617, 4634, 4637, 4638) in the Panamic Area; eighteen (4647, 4650, 4655, 4657, 4660, 4661, 4662, 4663, 4664, 4665, 4666, 4667, 4668, 4669, 4670, 4671, 4675, 4676) in the Peruvian Current; five (4689, 4691, 4695, 4697, 4699) in the Easter Island Eddy; one (4713) in the Galapagos Eddy; twenty-one (4679, 4681, 4683, 4701, 4705, 4706, 4707, 4709, 4711, 4719, 4724, 4728, 4730, 4731, 4732, 4733, 4734, 4736, 4737, 4739, 4740) in the South Equatorial Drift; three (4742, 4743, 4540) in the South Equatorial Current; two (4541, 4542) in the Equatorial Counter Current. There are thirteen records from the surface (Stations 4657, 4660 [Salpa], 4664, 4669, 4675, 4706 [Salpa], 4731, 4733, 4743, 4540, 4541, 4542, 4545); at ten of these

stations the species was taken in surface hauls only; at three stations (4657, 4664, 4675) in hauls from 300–0 fathoms as well as at the surface. At one station (4737) the species is recorded from 100–0 fathoms and 300–0 fathoms; at one station (4713) from 150–0 fathoms and 300–0 fathoms; at three stations (4681, 4724, 4732) from 800–0 fathoms and 300–0 fathoms; at four stations (4647, 4662, 4666, 4670) from 800–0 fathoms only. All the remaining records refer to hauls from 300–0 fathoms only. The species was taken also in surface waters in Acapulco Harbor, off the Mexican Current. This station is not included in the 127 stations mentioned above.

The temperature range of these sixty-three stations at the surface was 65°–85°; the average was 74.7°. At the thirteen stations in the surface catches of which the species was found, the surface temperature ranged from 67° to 80°; the average was 74.5°. At Acapulco it was 83°.

For the surface catches the following frequencies are recorded: — 4% at one station (4669); 3% at two stations (4542, 4545); 2% at one station (4675); 1% at two stations (4657, 4664); in the remaining cases the frequency was less than 1%. For the catches from 100, 150, 300, or 800 fathoms to the surface the records of frequency are as follows: — 40% at one station (4664); 10% at one station (4663); 6% at two stations (4613, 4666); 4% at one station (4662); 3% at two stations (4671, 4742); 2% at five stations (4609, 4634, 4689, 4713, 4740); 1% at twelve stations (4590, 4594, 4598, 4638, 4650, 4657, 4665, 4667, 4681, 4701, 4732, 4739); at the remaining stations the frequency is less than 1%. For the catch made in Acapulco Harbor the frequency of 1% is recorded.

Schütt (1895) does not give any information as to the type locality of *Phalacroma cuneus;* however, it is probably either Naples or in the Atlantic Ocean. Later investigators have shown this species to be widely distributed. The following authors have found it in the Atlantic, between lat. 40° N. and lat. 28° S.: — Ostenfeld (1898), Murray and Whitting (1899), Cleve (1901c, 1902b, 1903b), Stüwe (1909), and Jörgensen (1923). Cleve (1901c) recorded it from the Caribbean Sea. Jörgensen (1923) found it at a fairly great number of stations throughout the Mediterranean. It is also recorded from the Gulf of Lyons, Pavillard (1909, 1916). Naples, Schröder (1900a); Zacharias (1906). Ionian Sea, Schröder (1906a). Arabian Sea, Schröder (1906a); Cleve (1901a, 1903b); Ostenfeld and Schmidt (1901). Indian Ocean, Schröder (1906a); Cleve (1901a); Karsten (1907). Japan, Okamura (1912).

According to the authors noted, this species occurs in waters of the following temperatures and salinities.

	Temperature	Range	Number and Mean of Observations	Salinity	Range	Number and Mean of Observations
Murray and Whitting (1899)	79°					
Cleve (1901c)		56.8°–81.5°	28 73°		35.63–37.43	22 36.49
Cleve (1902b)			6 69.6°			6 36.24
Cleve (1903b)		60.3°–82.0°	6 75.7°		36.13–36.49	6 36.40
Stüwe (1909)	80.2°					

Only Schütt (1895), Okamura (1912), and Jörgensen (1923) give figures or descriptions by means of which their determinations of this form may be judged.

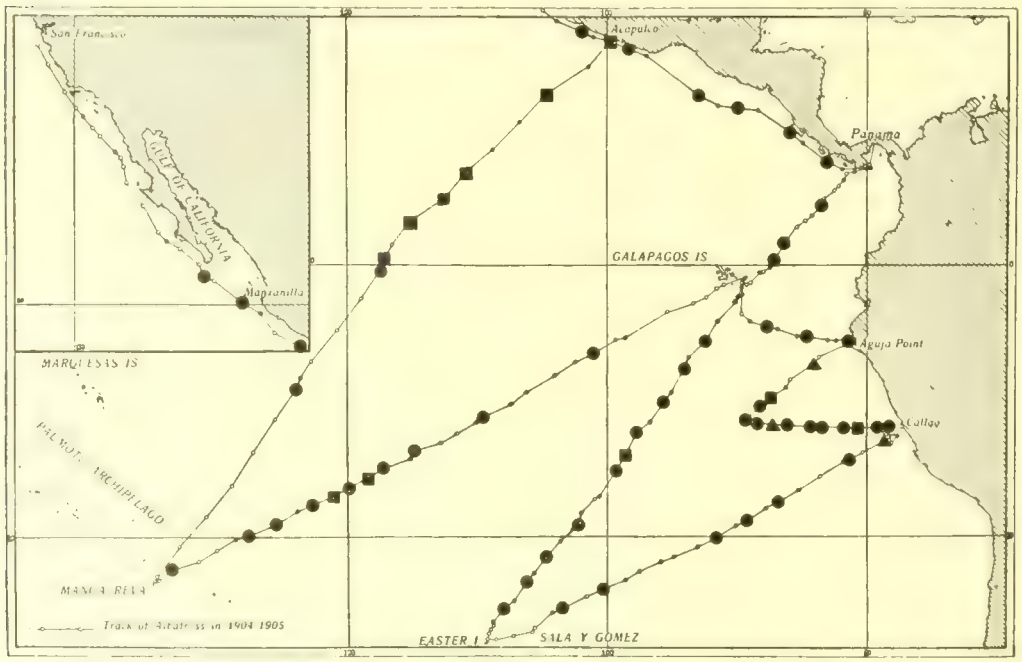

FIGURE 13.— Occurrence of *Phalacroma cuneus* Schütt. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

Phalacroma cuneus is eupelagic and widely distributed in tropical, subtropical, and warm-temperate seas. While previous writers have found it to be rare, it is one of the most abundant of the species of the genus found by the Expedition. In the Eastern Pacific it occurs throughout the whole area investigated. According to the records, there is a center of abundance in the relatively cool Peruvian Current. Out of the twenty-eight stations with frequencies of 1% or more, not less than eleven are in that Current; and all the stations with frequencies of 4% or more are located there. The frequent occurrence of *P. cuneus* in the coolest (65°–72°) of the regions investigated is the more noteworthy, since

the species has not been found as yet outside of tropical, subtropical, and warm-temperate waters. The relatively frequent occurrence of this species in our surface catches is another outstanding feature. Of the species of Phalacroma only *P. doryphorum* (twenty-six surface records) and *P. rapa* (twenty-two surface records) were found more frequently than *P. cuneus* (thirteen surface records) in the surface catches of the Expedition. Of *P. favus*, which next to *P. cuneus* was the most frequent species of this genus in the surface catches, there are only six surface records.

Phalacroma striatum Kofoid

Plate 2, fig. 5, 8. Figure 14:3; 15

Phalacroma striata Kofoid, 1907a, p. 195, pl. 12, fig. 73. Kofoid & Michener, 1911, p. 289.
Phalacroma striatum Jörgensen, 1923, p. 12, 43, fig. 12.

Diagnosis: — Body cuneate in lateral view, with very broadly rounded epitheca, and with posterior portion of hypotheca fairly broadly rounded; deepest at posterior cingular list; length: depth, 1.00–1.04: 1; longitudinal axis deflected posteroventrally at 6°–9°. In dorsal view cuneate; posterior portion of hypotheca narrowly rounded to acute; length: width, 1.34–1.54: 1. Posterior cingular list 0.20–0.24 the length of body from apex. Cingular lists with numerous simple or branched ribs, or reticulate. Left sulcal list extends to or almost to antapex; distance from R_1 to R_3 is 0.57–0.63 the length of body; R_2 is 0.13–0.18, and R_3 is 0.06–0.16 the greatest depth of body; widest somewhat in front of R_3; margin gently sigmoid, gently convex at R_3; R_3 inclined posteriorly at about 90°; irregularly and incompletely reticulate. Theca reticulate; 25–35 polygons border girdle posteriorly. Length, 102–136 μ.

Eastern tropical Pacific, Mediterranean, Guinea Current.

Description: — This is a comparatively large species, the body of which is cuneate in lateral view, with a rather low and very broadly rounded epitheca, with the posterior portion of the hypotheca fairly broadly rounded, with the greatest depth at the posterior cingular list, and about as deep as long. The ratio between the length and the depth of the body is 1.02 (1.00–1.04): 1. The longitudinal axis is deflected posteroventrally at an angle of 6°–9°.

The epitheca is about as deep as the hypotheca, very broadly and usually almost evenly convex, highest at or somewhat dorsally to the center, and moderately elevated above the anterior cingular list. The transverse furrow is somewhat concave, and its width is 0.35–0.50 the greatest height of the epitheca. The posterior cingular list is 0.22 (0.20–0.24) the length of the body from the apex.

The hypotheca tapers posteriorly and is somewhat deflected posteroventrally (see p. 131); its dorsal margin is almost straight, slightly convex or concave, or slightly sigmoid, concave anteriorly and convex posteriorly; its ventral margin is almost straight, gently concave or convex, or slightly irregular (Figure 14: 3); its postmargin is evenly and fairly broadly convex, and confluent with the dorsal and ventral margins. In dorsoventral view the body is cuneate, with broadly rounded epitheca, and with the posterior portion of the hypotheca narrowly rounded to acute; the side contours of the hypotheca are gently concave in the middle, or gently sigmoid, concave anteriorly and convex posteriorly; the ratio between the length and the width is 1.34–1.54: 1.

The cingular lists are subhorizontal and subequal; their width about equals or in some specimens slightly exceeds the width of the transverse furrow; each of these lists has, on each valve, about 35–45 straight or more or less irregular ribs, which often anastomose and form a more or less regular reticulum (Jörgensen, 1923, p. 12, fig. 12). The sulcus is about 0.45–0.55 the length of the hypotheca. The flagellar pore is about a girdle-width behind the junction of the cingulum and the sulcus. On the ventral side of the left valve two or three rather small pores are found on the sagittal suture, just in front of the anterior cingular list (Plate 2, fig. 5). The right sulcal list extends to or somewhat beyond the point midway between the fission rib and the posterior main rib of the left sulcal list; in some specimens its ventral margin, even in the widest region, does not quite extend to the ventral margin of the left sulcal list, but in others it does. The anterior half to two thirds of the free margin of this list is fairly deeply concave and is, at least in some specimens (Plate 2, fig. 8), strengthened by a marginal rib; the posterior portion of this margin, which forms a distinct angle with the anterior portion, is more or less convex, or sometimes almost straight. The greatest height of this list is located just behind the concavity. Along the base of this list a reticulum of about the same type as that of the thecal wall may be developed. The left sulcal list is unusually large. In most specimens it extends to or almost to the antapex, and the distance between the anterior and posterior main ribs is 0.57–0.63 the length of the body. The anterior main rib, when present, is about 0.08–0.10, the fission rib is 0.13–0.18, and the posterior main rib is 0.06–0.16 the greatest depth of the body. The greatest width of this list, which is located somewhere between the fission rib and the posterior main rib, is about 0.20–0.22 the greatest depth of the body. Anteriorly the free margin of this list is gently sigmoid, concave, or almost straight; posteriorly it is convex; in other words, this margin is gently convex at the posterior main rib, and not angular as in most

species of the genus. The main ribs of this list are rather weak and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.35–0.45 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of about 90°. Besides the main ribs, the left sulcal list has a "more or less distinct structure of incomplete areoles, which often present the impression of irregular radial striation" (Jörgensen, 1923, p. 12). There are no accessory lists or sails.

The thecal wall has a reticulum of medium-sized polygons, and each polygon has a small pore in the center; the reticulation often is "faint and thin-walled" (Jörgensen, 1923, p. 12). The polygons usually are about equal in size, and on each valve about 25–35 of them border the posterior margin of the girdle. In most specimens there are two rows of polygons in the transverse furrow, each row with 25–30 polygons on each valve. From a point near the middle of the right sulcal list a spine-like process projects into the cytoplasm.

Megacytic stages have not been recorded.

The proportions of three Expedition specimens were measured.

Dimensions: — Expedition specimens: Length of body, 108–115 μ (average, 111 μ; type, 108 μ). Greatest depth of body, 105–114 μ (average, 109 μ; type, 109 μ). Jörgensen (1923, p. 12): "Length of cell (height) almost equal to breadth in dorso-ventral direction, or somewhat greater; the latter 102–136 μ."

Variations: — Apart from variations in size, this species appears to be unusually constant.

Comparisons: — The description and figures of this species are based on the type material.

Phalacroma striatum is structurally very close to *P. cuneus*, *P. blackmani*, and *P. giganteum* (see *P. cuneus*, p. 127). It differs from *P. cuneus* in the larger size of its body (102–136 μ, as compared with 80–88 μ), and in its larger left sulcal list. From *P. blackmani* it is easily distinguished by its lack of parasagittal lists, and by the large size and the structure of its left sulcal list. From *P. giganteum* it differs in the smaller size of its body (102–136 μ, as compared with 148 μ), and in the large size and the structure of its left sulcal list.

The four species mentioned in the last paragraph form a natural systematic group, the CUNEUS group. The closest relative of *Phalacroma striatum*, outside of this group, presumably is *P. argus*. With regard to the characters in which the last two species resemble each other, see *P. argus* (p. 107). *Phalacroma striatum* is easily distinguished from *P. argus* by its low and broadly rounded epitheca, its cuneate hypotheca, and its exceptionally large left sulcal list. The

most striking feature of this relationship is that *P. argus* appears to be more closely related to *P. striatum* than to *P. cuneus*, although the latter species is smaller and has a smaller and less differentiated left sulcal list (compare, for instance, the directions of the posterior main ribs) and a simpler right sulcal list than *P. striatum*. The CUNEUS group probably evolved from an ancestral form of about the same habitus as *P. argus*.

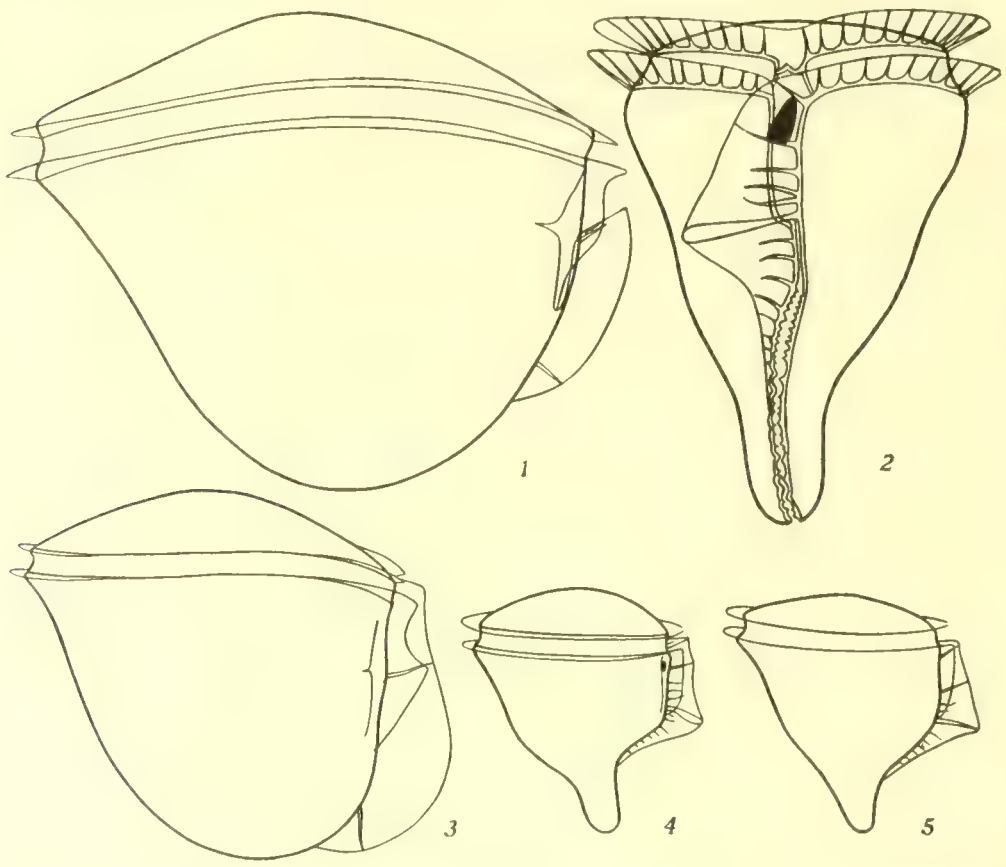

FIGURE 14. 1, *Phalacroma giganteum* Kofoid and Michener, right lateral view of right valve of type specimen. × 430. Station 4734 (300–0 fathoms). 3, *Phalacroma striatum* Kofoid, right lateral view. × 430. Station 4719 (300–0 fathoms). 2, 4, 5, *Phalacroma favus* Kofoid and Michener. 2, ventral view of type specimen; somewhat tilted. × 900. Station 4737 (300–0 fathoms). 4, 5, right lateral view; 4, from type specimen. × 430. Station 4737 (300–0 fathoms).

Occurrence: — *Phalacroma striatum* is recorded at twenty of the 127 stations. There are 0, 3, 3, 6, 6, and 2 stations on the six lines of the Expedition. Of these twenty stations, three (4634, 4637, 4638) are in the Panamic Area; one (4699) is in the Easter Island Eddy; two (4713, 4715) in the Galapagos Eddy; thirteen (4679, 4681, 4685, 4701, 4705, 4707, 4717, 4719, 4721, 4722, 4724, 4732, 4740) in the South Equatorial Drift; and one (4742) in the South Equatorial

Current. At two stations (4717, 4732) the species is recorded from 300–0 fathoms and 800–0 fathoms; at two stations (4701, 4721) from 800–0 fathoms only. All the remaining records refer to hauls from 300–0 fathoms only. In other words, the species has not been found as yet at the surface.

The temperature range of these twenty stations at the surface was 68°–81°; the average was 74.7°.

The frequency is less than 1% except at two stations (4732, 4742), where it is 1%.

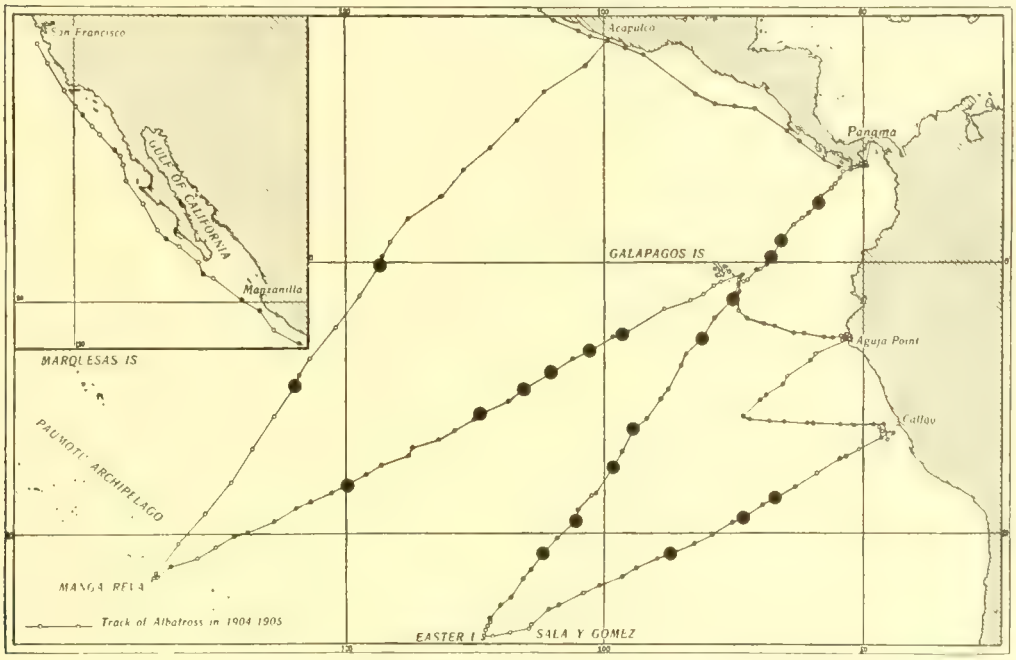

FIGURE 15.— Occurrence of *Phalacroma striatum* Kofoid. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

This species was first recorded by Kofoid (1907a) from Stations 4638 and 4719. Of these stations, 4638 is the type locality. Jörgensen (1923, p. 12), who found this species at two stations in the Mediterranean, the THOR Expedition, and in catches from the Guinea Current, German South Pole Expedition, 1903, writes as follows about its occurrence in the Mediterranean: "Undoubtedly one of the tropical species which come in at times from the Atlantic through the Straits of Gibraltar, and are as a rule only found later on in deeper water in the inner parts of the Mediterranean, where they seem to be able to exist for a more or less considerable time."

Phalacroma striatum is eupelagic and probably widely distributed in tropical,

subtropical, and warm-temperate seas. The most outstanding peculiarities of its distribution in the Eastern Pacific, according to our data, are its absence from surface waters, and its absence from the Californian, Mexican, and Peruvian Currents. The lack of surface records is noteworthy, since the species appears to be highly adapted to flotation. Compare, for instance, the size of the sulcal lists in this species and in the closely related *P. cuneus*, which has been found repeatedly in surface hauls.

Phalacroma giganteum Kofoid and Michener

Plate 2, fig. 2, 4; Plate 3, fig. 2. Figure 14: 1

Phalacroma gigantea Kofoid & Michener, 1911, p. 289.

Diagnosis: — Body cuneate in lateral outline, with very broadly rounded epitheca, and with posterior portion of hypotheca fairly broadly rounded; deepest at anterior cingular list; length : depth, 0.86 : 1; longitudinal axis deflected posteroventrally at 3°–4°. In dorsal view cuneate; posterior portion of hypotheca narrowly rounded to subacute; length and width subequal. Posterior cingular list about 0.25 the length of body from apex. Left sulcal list about 0.50 the length of body; distance from R_1 to R_3 is about 0.42 the length of body; R_2 is 0.09–0.10, and R_3 is 0.06–0.07 the greatest depth of body; widest about midway between R_2 and R_3; margin gently sigmoid, gently convex at R_3; R_3 inclined posteriorly at about 50°. With narrow parasagittal list on hypotheca. Theca faintly reticulate, with about thirty-five polygons bordering girdle posteriorly, or without reticulation. Length, 148 μ.

Eastern tropical Pacific.

Description: — This is an unusually large species, the body of which is cuneate in lateral outline, with a rather low and very broadly rounded epitheca, with the posterior portion of the hypotheca fairly broadly rounded, with the greatest depth at the anterior cingular list, and somewhat deeper than long. The ratio between the length and the depth of the body is 0.86: 1. The longitudinal axis is deflected posteroventrally at an angle of 3°–4°.

The epitheca is about as deep as the hypotheca, very broadly and almost evenly convex or with more or less flattened dorsal and ventral margins, highest at or somewhat dorsally to the center, and moderately elevated above the anterior cingular list. The transverse furrow is somewhat concave, and its width is about 0.50 the greatest height of the epitheca. The posterior cingular list is about 0.25 the length of the body from the apex. The hypotheca tapers posteriorly and is slightly deflected posteroventrally (see above); its dorsal margin is

almost straight, or slightly convex or concave, or slightly sigmoid, concave anteriorly and convex posteriorly; its ventral margin is moderately convex; its postmargin is evenly and fairly broadly convex, and confluent with the dorsal and ventral margins. In dorsoventral view the body is cuneate, with broadly rounded epitheca, and with the posterior portion of the hypotheca narrowly rounded to subacute; the side contours of the hypotheca are gently concave in the middle or nearly straight; the length and the width are subequal.

The cingular lists are subhorizontal and subequal; their width about equals, or in some specimens slightly exceeds, the width of the transverse furrow. Each of these lists has, on each valve, about 65–75 more or less straight, simple (always?) ribs. However, judging by one of our drawings, in one of the specimens these lists lacked ribs; this specimen was megacytic, and its thecal wall was faintly reticulated. The sulcus is about 0.40–0.45 the length of the hypotheca. The flagellar pore is somewhat less than a girdle-width behind the junction of the cingulum and the sulcus. On the ventral side of the left valve two pores of moderate size are found on the sagittal suture, just in front of the anterior cingular list. The right sulcal list extends to or somewhat beyond the point midway between the fission rib and the posterior main rib of the left sulcal list; anteriorly, where it is widest, it is about as wide as or somewhat narrower than the transverse furrow; posteriorly it tapers gradually; its free margin is concave anteriorly and posteriorly and convex in the middle. The left sulcal list is of moderate size. Its length is about 0.50 the length of the body, and the distance between the anterior and posterior main ribs is about 0.42 the length of the body. The anterior main rib, when present, is about 0.07–0.08, the fission rib 0.09–0.10, and the posterior main rib 0.06–0.07 the greatest depth of the body. The greatest width of this list, which is located about midway between the fission rib and the posterior main rib, is about 0.09 the greatest depth of the body. The free margin of this list is either gently and almost evenly convex, or it is gently sigmoid, concave anteriorly and convex posteriorly; in other words, it is gently convex at the posterior main rib, and not angular as in most species of the genus. The main ribs of this list are straight and rather weak, and not club-shaped or otherwise modified. The distance between the anterior main and the fission rib is about 0.35–0.40 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of about 50°. Except the main ribs, no structure was observed in this list. A parasagittal list, which forms a direct continuation of the left sulcal list, extends on the right valve of the hypotheca from the left sulcal list to the posterior cingular list. The width of this

parasagittal list is about one third of that of the transverse furrow, and the list either has fine riblets or is without structure. In Plate 2, fig. 2, which was drawn from a detached valve, there is no parasagittal list.

The theca is fragile. Its surface either is smooth, with numerous small, regularly spaced pores, or it has a faint reticulation of medium-sized polygons, each with a small pore in its center. In the specimens with the thecal wall reticulated, there are two rows of polygons in the transverse furrow; each of these rows has on each valve about thirty-five polygons. The polygons of the epitheca and of the hypotheca are of about the same size as those in the transverse furrow. From a point near the middle of the right sulcal list a spine-like process projects into the cytoplasm.

Megacytic stages of this species occur (Plate 3, fig. 2).

The dimensions of two of the specimens were measured.

Dimensions: — Length of body, 148 μ. Greatest depth of body, 173 μ.

Comparisons: — The description and drawings of this species are based on the type material.

Phalacroma giganteum is structurally very close to *P. cuneus*, *P. blackmani*, and *P. striatum* (see p. 127, section on comparisons). It is easily distinguished from these species by its large size. Indeed, as its name suggests, it is the largest-known species of this genus.

While the relatively small *Phalacroma cuneus* has a rather heavy theca, the large *P. giganteum* is characterized by its thin and apparently very fragile theca. The reduced thickness of the thecal wall in the latter species may be interpreted as an adaptation to flotation, counterbalancing the reduction in the relative surface of resistance caused by the increase in the size of the body.

Occurrence: — *Phalacroma giganteum* is recorded at five of the 127 stations. There are 0, 0, 0, 2, 2, and 1 stations on the six lines of the Expedition. Of these five stations, two (4695, 4699) are in the Easter Island Eddy; two (4730, 4734) in the South Equatorial Drift; one (4742) in the South Equatorial Current. All records refer to catches from 300–0 fathoms only.

The temperature range of these five stations at the surface was 74°–81°; the average was 77.2°.

The frequency is less than 1% except at one station (4699), where it is 1%.

Phalacroma giganteum is eupelagic and of rare occurrence in tropical waters. Its occurrence in the Eastern Pacific resembles that of *P. striatum*. It is absent from surface waters and has not been found in the California Current, Mexican Current, Panamic Area, and Peruvian Current.

5. Rapa Group. None of the four more or less primitive members of this group was taken by the Expedition. Only the top members, viz., *Phalacroma rapa, P. favus,* and *P. hindmarchi,* were recorded.

Phalacroma rapa Stein

Figure 16, 17

Phalacroma rapa Stein, 1883, p. 23, pl. 19, fig. 5–8. Bütschli, 1885, pl. 55, fig. 2. Whitelegge, 1891, p. 184. Hensen, 1895, p. 190; 1911, p. 166, 167. Lemmermann, 1899a, p. 372; 1901a, p. 373; 1905a, p. 35. Schröder, 1900a, p. 19. Cleve, 1901a, *partim*, p. 17; 1901c, p. 273; 1902b, p. 37; 1903b, p. 348. Ostenfeld & Schmidt, 1901, p. 176. Entz, 1902b, p. 94; 1905, p. 111. Chun, 1903, p. 75, fig. d. Karsten, 1906, p. 188; 1907, p. 238, 249, 299, 348. Zacharias, 1906, p. 509, 526, 536. Stüwe, 1909, p. 238, 252, 288. Nathansohn, 1910b, p. 61, fig. 29: 5–8. Pavillard, 1916 (*non* 1915a, p. 2, fig. A), p. 47, 48, 49, 55, fig. 13A; 1923a, p. 879. Forti, 1922, p. 107, 190, 208, fig. 113. Jörgensen, 1923 (*non* 1915a, p. 2, fig. A), p. 14, 15, 16, 44, fig. 14.

Phalacroma mitra Okamura, 1907 (*non* 1912), p. 134, pl. 5, fig. 45.

Diagnosis: — Body subcuneate in lateral view; epitheca moderately convex to almost flat; posterior portion of hypotheca narrowly rounded to subacute, but not mammilliform; ventral margin of hypotheca strikingly angular at R_3 of left sulcal list; deepest at or somewhat behind girdle; length: depth, 1.00–1.34: 1; longitudinal axis deflected posteroventrally at 0°–5°. In dorsal view cuneate; hypotheca very narrowly rounded to subacute posteriorly, and its side contours gently concave or gently undulating. Posterior cingular list 0.10–0.25 the length of body from apex. Left sulcal list 0.36–0.55 the length of body; distance from R_1 to R_3 is 0.26–0.44 the length of body; R_2 is 0.09–0.14, and R_3 is 0.13–0.20 the greatest depth of body; margin forms angle of 75°–100° at R_3; R_3 inclined posteriorly at 0°–25°; sometimes with faint reticulation. Theca reticulate; 20–25 polygons border girdle posteriorly. Length, 70–95 μ.

Widely distributed in tropical to temperate seas.

Description: — A medium-sized species, the body of which is subcuneate in lateral view, with moderately convex to almost flat epitheca, with the posterior portion of the hypotheca narrowly rounded to subacute, but not mammilliform, with the ventral margin of the hypotheca strikingly angular at the posterior main rib of the left sulcal list, and with the greatest depth at or somewhat behind the girdle. The ratio between the length and the depth of the body is 1.19 (1.00–1.34): 1. The longitudinal axis is deflected posteroventrally at an angle of 0°–5°.

The epitheca is about as deep as the hypotheca or slightly less, moderately and evenly convex to almost flat, highest in or near the center, and moderately to but slightly elevated above the anterior cingular list. The transverse furrow usually is somewhat concave, but sometimes flat or even slightly convex, and its width is 0.4–1.0 the greatest height of the epitheca. The posterior cingular list is

0.18 (0.10–0.25) the length of the body from the apex. The hypotheca is often slightly deflected posteroventrally (see p. 139). The dorsal margin (from the girdle to the antapex) is somewhat variable in shape; in most of the specimens it is evenly and moderately convex; in other specimens (see Stein, 1883, pl. 19, fig. 5, and Figure 16: 3) it forms a more or less pronounced, broadly rounded corner somewhat behind the middle, and in front of and behind this corner it is almost straight or even slightly concave. The portion of the ventral margin that is in front of the posterior main rib of the left sulcal list is almost straight or somewhat concave or convex; it either is about perpendicular to the girdle, or it is inclined posteroventrally at 1°–30°. The portion of this margin that is behind the posterior main rib of the left sulcal list is 1.0–2.5 the length of the anterior portion, gently to moderately concave, and forms with the anterior portion a very pronounced, although rounded, corner. The posterior portion of the hypotheca is narrowly rounded to subacute but not mammilliform. In dorsal view the body is cuneate, with very broadly rounded to flat epitheca, with the hypotheca very narrowly rounded to subacute posteriorly, and with the side contours of the hypotheca evenly and gently concave, or gently undulating, *i.e.*, slightly concave just in front of and behind the middle; the ratio between the length and the width is about 1.5: 1.

The cingular lists are subhorizontal, subequal, and about as wide as the transverse furrow; each of them has, on each valve, about 20–30 rather strong, straight, simple, and nearly equidistant ribs. The sulcus is about 0.30–0.40 the length of the hypotheca. The right sulcal list varies in length; sometimes it ends at the fission rib of the left sulcal list, and sometimes it extends to or even slightly beyond the posterior main rib of the last-mentioned list; in most specimens it is subtriangular, decreasing gradually in width posteriorly; in others it is of subequal width throughout the greater portion of its length; anteriorly it is about as wide as or somewhat narrower than the transverse furrow. The left sulcal list is of moderate size to rather small. Its length is 0.36–0.55 the length of the body, and the distance between the anterior and posterior main ribs is 0.26–0.44 the length of the body. It extends to or somewhat beyond the ventral angular process of the body (Figure 16: 1, 2). The anterior main rib, when present, is about 0.07–0.14, the fission rib 0.09–0.14, and the posterior main rib 0.13–0.20 the greatest depth of the body. Behind the posterior main rib this list either decreases suddenly in width, or it is somewhat decurrent (Figure 16: 1, 2). Between the anterior and posterior main ribs, the free margin of this list is almost straight, gently concave or convex, or slightly irregular; at the posterior main rib it forms

an angle of 75°–100°; behind the last-mentioned rib it usually is straight, but sometimes gently convex or concave. The main ribs of this list are of moderate strength, and generally straight or almost so; in exceptional cases (Figure 16: 2) the posterior one of them is slightly club-shaped. The distance between the anterior main rib and the fission rib is 0.25–0.53 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 0°–25°. In a few specimens (Figure 16: 3) this list has one or a few short ribs besides the three main ribs, and sometimes it is characterized by a faint reticulation (Jörgensen, 1923, p. 14). There are no accessory lists or sails in the specimens examined by us. The specimen figured by Jörgensen (1923, fig. 14) appears to have had a very short and narrow parasagittal list on the antapex.

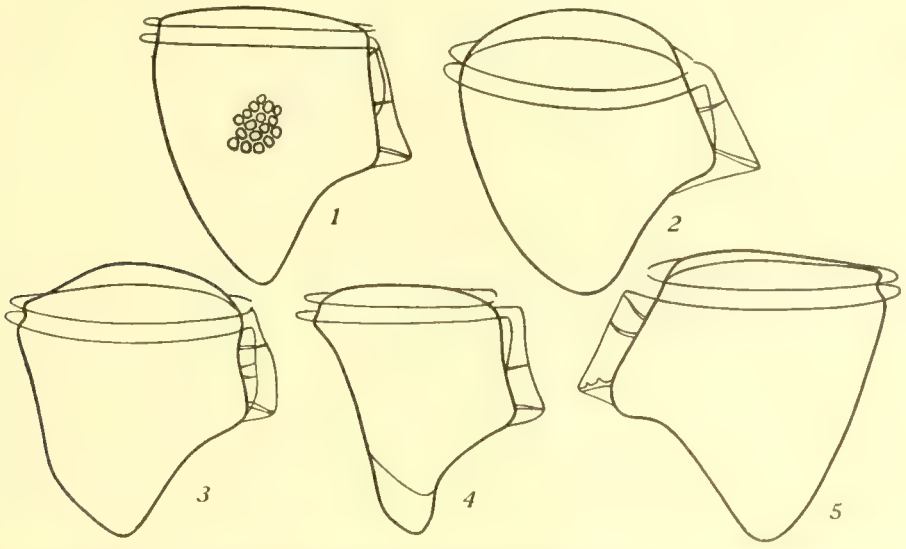

FIGURE 16.— *Phalacroma rapa* Stein. 1–4, right lateral view; 5, left lateral view. Structure of thecal wall indicated only in 1. 2, 3, 5, somewhat tilted. 4, specimen in which posterior portion of right valve is much shorter than that of left valve. × 430. 1, from Station 4709 (300–0 fathoms); 2, from Station 4605 (300–0 fathoms); 3, from Station 4681 (300–0 fathoms); 4, from Station 4681 (800–0 fathoms); 5, from Station 4695 (300–0 fathoms).

The thecal wall has a reticulum of medium-sized, subequal polygons, each with a small central pore. There are twenty to twenty-five of them bordering the posterior margin of the girdle on each valve, and two rows of polygons in the transverse furrow, each row with twenty to twenty-five polygons on each valve.

Megacytic stages of this species were seen by Stein (1883) and by Pavillard (1916).

The proportions of four of the Expedition specimens, and of the specimens represented by Stein (1883), Okamura (1907), and Pavillard (1916) were measured.

Dimensions: — Length of body, 77–87 μ (average, 81.6 μ). Greatest depth of body, 58–70 μ (average, 67.4 μ). The right valve of the specimen represented by Figure 16: 4 is 65.5 μ long. We do not know the size of the type specimen (Stein, 1883, pl. 19, fig. 5); according to his statement (1883, p. 31), however, this specimen was somewhere between 95–145 μ long and 70–108 μ deep. The specimen figured by Okamura (1907, pl. 5, fig. 43) was 70 μ long and 70 μ deep; the one figured by Pavillard (1916, fig. 13A), 80 μ long and 64 μ deep. The specimens measured by Jörgensen (1923) were 72–85 μ long and 60–64 μ deep.

Variations: — Some of the Pacific specimens of *Phalacroma rapa* examined (Figure 16: 3) conform rather closely to Stein's (1883) Plate 19, fig. 5. The anterior portion of the dorsal margin of the body in these is nearly straight or even slightly concave and forms with the posterior portion of this margin a broadly rounded but distinct corner; and the portion of the ventral margin of the body that is in front of the posterior main rib of the left sulcal list is somewhat concave or almost straight, and nearly parallel to the longitudinal axis of the body. However, most of the specimens found in the material of the Expedition (Figure 16:5) have a habitus that resembles very closely that of *P. mitra* Okamura (1907, pl. 5, fig. 43). These specimens are characterized by an evenly and gently convex dorsal margin of the body, and the portion of the ventral margin of the body which is in front of the posterior main rib of the left sulcal list is nearly straight or slightly convex or concave, and has a more or less decided posteroventral inclination. In other words, most of the Expedition specimens differ rather strikingly from the type as figured by Stein (1883). Between the extreme forms of *P. rapa*, as figured by Stein (1883) and by Okamura (1907), there is in the Expedition material a nearly continuous series of intergrading specimens.

These differences, although very striking, probably do not indicate that *Phalacroma rapa* is composed of two or more closely related systematic units. They probably are the results of regulatory processes of growth and absorption following binary fission. Figure 16: 4 shows that the two valves of the theca may be very different; the left valve of the specimen represented is decidedly longer than the right. In another specimen the left valve had an angular, and the right valve an evenly and gently convex dorsal margin.

According to Stein (1883, p. 23), the epitheca of *Phalacroma rapa* is "scheibenförmig;" according to Jörgensen (1923, p. 14), it is "flat, in profile hardly projecting beyond the girdle." In the Expedition specimens, as well as in those figured by Okamura (1907, pl. 5, fig. 43) and by Pavillard (1916, fig. 13A), it is of moderate convexity; in the Expedition specimens the degree of this convexity

is somewhat variable. Following this evidence, it appears probable that these variations in the convexity and the relative height of the epitheca are partly due to regulatory processes; partly they may be apparent, due to the tilting of some of the specimens examined. In addition, we have no evidence that they are genetic.

According to Pavillard (1916, p. 55) this species exhibits about the same variations in the Gulf of Lyons as in the Eastern Pacific (see Forti, 1922, p. 107).

Comparisons: — The structurally closest-known relative of *Phalacroma rapa* is *P. mitra*. Indeed, these two forms are so similar that Cleve (1901c, p. 273) considered them as identical, and Pavillard (1916, p. 53) and Jörgensen (1923, p. 15) held their specific separation as questionable. The data available at the present time are not sufficient to settle the question as to whether or not these two forms are specifically distinct. The most important distinguishing characteristic appears to be the shape of the ventral margin of the body. In *P. rapa* this margin is more or less strikingly angular at the posterior end of the left sulcal list, while in *P. mitra*, according to Schütt's (1895, pl. 4, fig. 18: 1) figure of the type specimen, it is strongly and evenly sigmoid. In addition, *P. mitra* has a somewhat larger right sulcal list than has *P. rapa*.

Another very close relative of *Phalacroma rapa* is *P. favus*. Sometimes these two species are so similar that even their specific differentiation is difficult; compare, for instance, Pavillard's (1916) figure 13A and our Figure 14: 5. As far as known, *P. favus* can always be distinguished from *P. rapa* by its relatively longer and more decurrent left sulcal list, which has a fairly great number of short ribs besides the three main ribs. Furthermore, the posterior portion of the hypotheca in *P. favus* is somewhat more contracted, *i.e.*, mammilliform, than in *P. rapa*.

Phalacroma dolichopterygium, *P. acutum*, and *P. hindmarchi* are, next to *P. mitra* and *P. favus*, the nearest in structure to *P. rapa*. *Phalacroma mitra* may be regarded as a connecting link between *P. rapa* and *P. dolichopterygium*, and the last species (figured by Jörgensen, 1923, fig. 15) as intermediate between *P. mitra* and *P. acutum*. In *P. acutum* the epitheca is relatively high and the ventral margin of the hypotheca is rounded angular at the posterior main rib of the left sulcal list. *Phalacroma dolichopterygium* has the hypotheca of about the same shape as in *P. acutum*, but its epitheca is about as low as in *P. mitra* and *P. rapa*. *Phalacroma hindmarchi*, on the other hand, appears to represent an independent evolutionary branch of this group of species in which the progressive reduction of the height of the epitheca has been inhibited, while the tendency to constrict the posterior portion of the hypotheca into a mammilliform projection has been

carried out to about the same extent as in the highly differentiated *P. favus*. *Phalacroma rapa* is readily distinguished from *P. dolichopterygium*, *P. acutum*, and *P. hindmarchi* by the pronounced angularity of the ventral margin of its body.

All the species mentioned in this section probably evolved from a regularly obovoidal species of about the same habitus as *Phalacroma vastum*.

The great similarity between *Phalacroma rapa* and *P. mitra* makes a partial confusion of these two forms by previous investigators appear very probable. The bibliographical list of *P. rapa* has therefore been made very conservative, but includes a list of all the references to *P. rapa*, except Pavillard (1915a, p. 2, fig. A), which refers to *P. mitra*, according to Pavillard's (1916, p. 54, footnote) own statement. However, it should be remembered that the assignment of *P. mitra* Pavillard (1916) must be regarded as somewhat uncertain. As mentioned in the last section, the shape of the ventral margin of the body appears to be the most important morphological difference between *P. rapa* and *P. mitra*. The ventral margin of the specimen of *P. mitra* figured by Pavillard (1916, fig. 13B) is strikingly angular at the posterior end of the left sulcal list (just as in *P. rapa*), its anterior half is gently convex, and its posterior half gently concave. In the type specimens of *P. mitra* (Schütt, 1895, pl. 4, fig. 18:1), on the other hand, this margin is strongly and evenly sigmoid. (See Pavillard, 1923a, p. 879.) Forti's (1922, pl. 7, fig. 109) determination of *P. mitra* evidently is based on Pavillard's (1916) conception of this species. Only one reference to *P. mitra* has been included in our bibliographical list of *P. rapa*, viz., *P. mitra* Okamura (1907); see the section on the variations; also Pavillard (1916, p. 54), Jörgensen (1923, p. 15), and Pavillard (1923a, p. 879). (On the other hand, *P. mitra* Okamura, 1912, is not a synonym of *P. rapa* Stein.) Jörgensen (1923, p. 15) notes that *P. mitra* Murray and Whitting (1899) is "doubtless" *P. rapa* Stein. This statement may be correct, but there is no morphological evidence as yet bearing on the question. Cleve (1901c, p. 273) includes *P. mitra* Schütt as a synonym of *P. rapa* Stein.

Even though the extent of the confusion of *Phalacroma rapa* and *P. mitra* by previous investigators cannot be fully established, there are reasons to assume that, with the exceptions mentioned in the last paragraph, it is not very great and that, therefore, the bibliographical list of *P. rapa* is fairly correct. This statement is based on the fact that *P. rapa* and *P. mitra* are recorded as specifically distinct by most of the investigators, Ostenfeld and Schmidt (1901), Zacharias (1906), Karsten (1906, 1907), Stüwe (1909), and Hensen (1911), who do not give any descriptions or figures by means of which their determinations may be checked.

Occurrence: — *Phalacroma rapa* is recorded at fifty-three of the 127 stations. There are 17, 9, 10, 7, 6, and 4 stations on the six lines of the Expedition. Of these fifty-three stations, two (4580, 4583) are in the California Current; nine (4587, 4590, 4594, 4596, 4598, 4600, 4604, 4605, 4607) are in the Mexican Current; eleven (4609, 4613, 4615, 4617, 4619, 4624, 4634, 4635, 4637, 4640, 4644) in the Panamic Area; six (4650, 4661, 4665, 4666, 4676, 4678) in the Peruvian Current; six (4689, 4691, 4692, 4695, 4697, 4699) in the Easter Island Eddy; seventeen (4679, 4680, 4681, 4683, 4685, 4701, 4705, 4709, 4711, 4719, 4721, 4722, 4724, 4737, 4739, 4740, 4741) in the South Equatorial Drift; two (4742, 4743) in the South Equatorial Current. There are twenty-two records from the surface (Stations 4590, 4596, 4600, 4604, 4607, 4615, 4617, 4619, 4624, 4635, 4640, 4644, 4650, 4661 [Salpa], 4666, 4676, 4678, 4680, 4692, 4709 [Salpa], 4741, 4743); at eighteen of these stations the species was taken in surface hauls only; at four stations (4590, 4617, 4650, 4709) in hauls from 300–0 fathoms as well as at the surface. At one station (4737) the species is recorded from 100–0 fathoms and 300–0

fathoms; at four stations (4681, 4689, 4701, 4724) from 800–0 fathoms and 300–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these fifty-three stations at the surface was 67°–85°; the average was 76.2°. At the twenty-two stations in the surface catches of which the species was found, the surface temperature ranged from 67° to 84°; the average was 76.0°.

For the surface catches the following frequencies are recorded: —2% at three stations (4615, 4624, 4650), 1% at three stations (4600, 4619, 4666), and less than 1% in the remaining cases. For the catches from 100, 300, or 800 fathoms to the

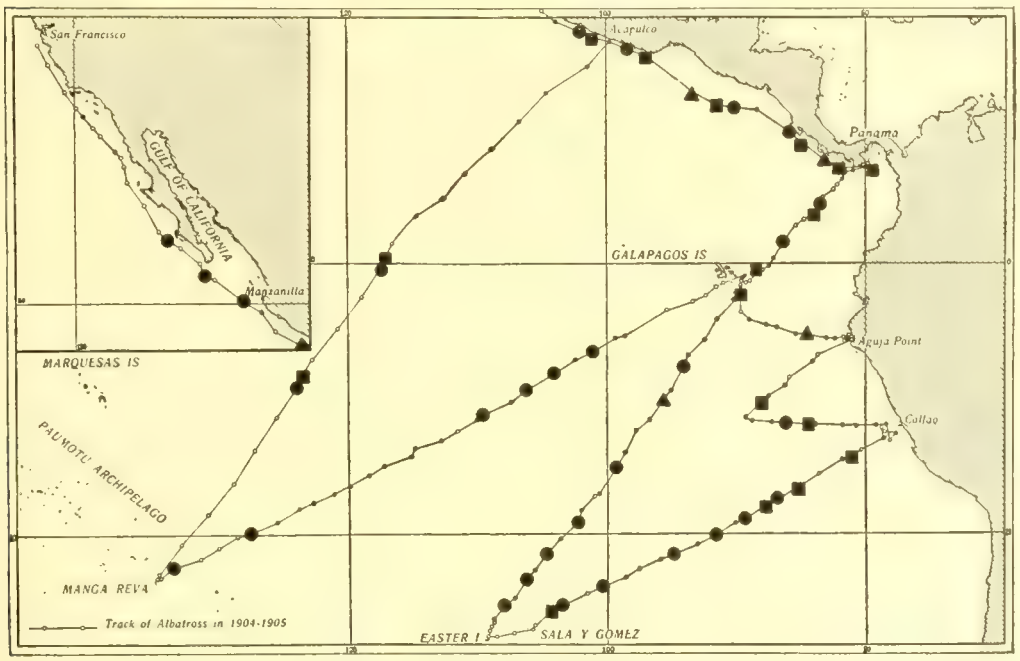

FIGURE 17.— Occurrence of *Phalacroma rapa* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

surface the records of frequency are as follows: —5% at one station (4709), 3% at one station (4695), 2% at one station (4697), 1% at seven stations (4598, 4613, 4617, 4681, 4689, 4701, 4721), and less than 1% at the remaining stations.

The species was first recorded by Stein (1883) "aus dem Atlantischen Meer und der Südsee." Hensen (1895, 1911) found it at a great number of stations throughout the tropical, subtropical, and warm-temperate regions of the Atlantic; Cleve (1901c, 1902b, 1903b), at a fairly great number of stations in the Atlantic, between lat. 42° N. and lat. 20° S., in the Caribbean Sea, in the Arabian Sea, and the Indian Ocean and recorded it at lat. 36°–37° N. and long. 10° E.–5° W.;

Karsten (1906) in the Atlantic, at lat. 5° N. and long. 13° W.; Stüwe (1909) off the west coast of Africa, between lat. 4° N. and lat. 9° N.; Jörgensen (1923) in the Bay of Cadiz, off the coast of Portugal, and southwest of Brittany, and at a fairly great number of stations in various parts of the Mediterranean; Pavillard (1916) in the Gulf of Lyons; Forti (1922) in the Ligurian Sea; Schröder (1900a) at Naples; Zacharias (1906) at Naples and in the Adriatic; Entz (1902b, 1905) in the Adriatic Sea. Ostenfeld and Schmidt (1901) found it in the Gulf of Aden; Karsten (1907) in the Indian Ocean; Whitelegge (1891) on the east coast of Australia; and Okamura (1907) in Japanese waters.

According to the authors noted, this species occurs in waters of the following temperatures and salinities.

	Temperature	Range	Number and Mean of Observations		Salinity	Range	Number and Mean of Observations	
Cleve (1901c)		56.0°–82.0°	39	70.0°		33.44–37.63	28	35.80
Cleve (1902b)	72.6°						12	36.27
Cleve (1903b)		59.2°–83.0°	13	70.0°		36.02–37.29	13	36.59
Ostenfeld and Schmidt (1901)	79.5°							
Stüwe (1909)	80.6°–82.8°							

Of the writers who have contributed to our knowledge of the distribution of this species, only Stein (1883), Okamura (1907), Pavillard (1916), Forti (1922), and Jörgensen (1923) give descriptions or figures by means of which their determinations may be judged. It should be mentioned that Cleve (1901c, p. 273) gives *Phalacroma mitra* Schütt as a synonym of *P. rapa* Stein. Some of the data referred to *P. rapa* by Cleve therefore may be referable to *P. mitra*.

This is a eupelagic species occurring in tropical, subtropical, and temperate regions of all seas. According to the Expedition records it is almost evenly distributed throughout the area investigated. It probably has its optimum habitat in deeper waters, within the levels of photosynthesis, but it appears to occur more frequently at the surface than most of the other species of Phalacroma. Indeed, of the species of this genus only *P. doryphorum* (twenty-six surface records) was found more frequently than *P. rapa* (twenty-two surface records) in the surface catches. Of *P. cuneus* and *P. favus*, which next to *P. rapa* were the most frequent in the surface catches, there are only thirteen and six records, respectively.

Phalacroma favus Kofoid and Michener

Plate 2, fig. 7. Figure 14: 4, 5

Phalacroma favus Kofoid & Michener, 1911, p. 289. Pavillard, 1923a, p. 879.
Phalacroma hindmarchii Pavillard, 1916, p. 53; cf. 1923a, p. 879.
?Phalacroma favus Jörgensen, 1923, p. 15, 16, 43, fig. 16.
Phalacroma simulans Jörgensen ms., 1923, p. 15.

Diagnosis: — Body subcuneate in lateral view; epitheca very broadly rounded; posterior portion of hypotheca constricted, mammilliform; ventral margin of hypotheca broadly rounded or somewhat angular at R_3 of left sulcal list; deepest at posterior cingular list; length: depth, 1.14–1.21 : 1; longitudinal axis deflected posteroventrally at 5°–10°. In dorsal view cuneate; hypotheca very narrowly rounded to subacute posteriorly, and its side contours gently undulating; length: width, 1.45–1.50 : 1. Posterior cingular list 0.21–0.27 the length of body from apex. Left sulcal list 0.50–0.65 the length of body; distance from R_1 to R_3 is 0.25–0.31 the length of body; unusually decurrent behind R_3; R_2 is 0.12–0.14, and R_3 is 0.14–0.22 the greatest depth of body; margin forms angle of 100°–130° at R_3; R_3 inclined posteriorly at 5°–30°; with about 8–15 short riblets. Theca reticulate; 20–25 polygons border girdle posteriorly. Length, 54–83 μ.

Probably widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is subcuneate in lateral view, with very broadly rounded epitheca, with the posterior portion of the hypotheca constricted and mammilliform, with the ventral margin of the hypotheca broadly rounded or somewhat angular at the posterior main rib of the left sulcal list, and with the greatest depth at the posterior cingular list. The ratio between the length and the depth of the body is 1.18 (1.14–1.21) : 1. The longitudinal axis is deflected posteroventrally at 5°–10°.

The epitheca is about as deep as the hypotheca or slightly less, very broadly convex, highest in or near the center, and moderately elevated above the anterior cingular list. The transverse furrow is somewhat concave, and its width is 0.50–0.67 the greatest height of the epitheca. The posterior cingular list is 0.24 (0.21–0.27) the length of the body from the apex. The hypotheca is somewhat deflected posteroventrally (see above). The dorsal margin, from the girdle to the antapex, is gently undulating, convex in the middle, and concave anteriorly and posteriorly; or its anterior half is almost straight and its posterior half gently concave (Jörgensen, 1923, fig. 16). The portion of the ventral margin that is in front of the posterior main rib of the left sulcal list is almost straight or gently convex or concave, and about perpendicular to the girdle. The portion of this margin that is behind the posterior main rib of the left sulcal list is 1.7–2.7 the length of the anterior portion, and moderately to rather strikingly concave. At the mentioned rib this margin is either broadly rounded or somewhat angular. The posterior portion of the hypotheca is constricted and mammilliform, and the antapex is narrowly rounded to subacute. In dorsal view the body is cuneate, with very

broadly convex epitheca and with the posterior portion of the hypotheca narrowly rounded to subacute; the side contours of the hypotheca are gently undulating, convex in the middle, and concave anteriorly and posteriorly; the ratio between the length and the width is 1.45–1.50: 1.

The cingular lists are subhorizontal, subequal, and about as wide as or slightly narrower than the transverse furrow; each of them has, on each valve, twenty to thirty rather strong, straight, simple, and nearly equidistant ribs. The sulcus is about 0.30–0.40 the length of the hypotheca. The flagellar pore is at the junction of the sulcus and the cingulum. The right sulcal list extends to the posterior main rib of the left sulcal list; in some specimens it is subtriangular, decreasing gradually in width posteriorly, in others it is of subequal width throughout the greater portion of its length; anteriorly it is about as wide as or somewhat narrower than the transverse furrow. The left sulcal list is of moderate size. Its length is 0.50–0.65 the length of the body, and the distance between the anterior and posterior main ribs is 0.25–0.31 the length of the body. It extends to the base of the posterior mammilliform projection of the body. The anterior main rib is 0.08–0.11, the fission rib 0.12–0.14, and the posterior main rib 0.14–0.22 the greatest depth of the body. Behind the posterior main rib this list is unusually decurrent. Between the anterior and posterior main ribs, the free margin of this list is nearly straight, gently convex, or gently concave between the anterior main rib and the fission rib as well as between the fission rib and the posterior main rib; at the posterior main rib it forms an angle of 100°–130°; behind the last-mentioned rib it is straight or gently concave. The main ribs of this list generally are of moderate strength and straight or almost so; in exceptional cases, for instance, in the type specimen, the posterior rib is club-shaped. The distance from the anterior main rib to the fission rib is 0.33–0.50 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 5°–30°. Besides the main ribs, this list has about eight to fifteen short riblets. At least in some specimens (Jörgensen, 1923, fig. 16) the left sulcal list is continued by a very narrow parasagittal list extending around the posterior portion of the hypotheca.

The thecal wall has a reticulum of medium-sized, subequal polygons, each with a small pore in the center. There are twenty to twenty-five of them bordering the posterior margin of the girdle and two rows in the transverse furrow, each with twenty to twenty-five polygons on each valve.

Megacytic stages were seen by Jörgensen (1923, p. 16).

The proportions of two of the Expedition specimens and the one represented by Jörgensen (1923) were measured.

Dimensions: — Length of body, 72–76 μ (average, 74.3 μ; type, 76 μ). Greatest depth of body, 62.7–63.6 μ (average, 63.2 μ; type, 62.7 μ). The specimens measured by Jörgensen (1923, p. 15) formed two size classes, the one 81–83 μ long and 68–71 μ deep, the other 54–62 μ long and 54 μ deep.

Variations: — Judging by the material thus far examined, this species appears to be fairly constant. Most of the specimens examined and the specimen represented by Jörgensen (1923, fig. 16) are strikingly similar. The most variable characters are the size of the body and the shape of the posterior portion of the hypotheca.

Comparisons: — The description and figures of *Phalacroma favus* are based on the type material.

Phalacroma rapa probably is structurally the closest relative of *P. favus*. Indeed, these two forms sometimes are so similar that even their specific differentiation is difficult; compare Pavillard (1916, fig. 13A) and Figure 14: 5. However, we do not agree with Jörgensen's (1923, p. 16) statement that *P. favus* is so closely related to *P. rapa* "that there might be some grounds for regarding it as a variety of that species." The most important distinguishing characteristics are:— (*1*) *P. favus* has a relatively longer and more decurrent left sulcal list, which has a fairly great number of short riblets besides the three main ribs; (*2*) the posterior portion of the hypotheca in *P. favus* is somewhat more contracted, *i.e.*, mammilliform, than in *P. rapa*. *P. favus* is most easily distinguished from *P. hindmarchi* by its lower epitheca, its relatively longer and more decurrent left sulcal list, which has a fairly great number of short riblets besides the three main ribs, and the polygonate reticulation of its theca. It differs from *P. mitra*, *P. dolichopterygium*, and *P. acutum* in the shape and structure of its left sulcal list and in the mammilliform shape of the posterior portion of its hypotheca. See *P. rapa*, p. 143, and Jörgensen, 1923, p. 15, 16.

Occurrence: — *Phalacroma favus* is recorded at twelve of the 127 stations. There are 6, 1, 0, 0, 2, and 3 stations on the six lines of the Expedition. Of these twelve stations, six (4587, 4590, 4592, 4594, 4604, 4545) are in the Mexican Current; one (4617) is in the Panamic Area; one (4665) is in the Peruvian Current; three (4730, 4737, 4741) are in the South Equatorial Current; one (4542) is in the Equatorial Counter Current. At one of these stations (4617) this species was taken in a surface haul as well as in a haul from 300–0 fathoms; at five stations (4592, 4604, 4741 [Salpa], 4542, 4545) in surface hauls only. All the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these twelve stations at the surface was 68°–84°;

the average was 80.2°. At the six stations in the surface catches of which this species was found, the surface temperature ranged from 78° to 84°; the average was 80.8°.

At two stations (4604, 4542) the frequency is 1%; in the remaining cases it is less.

The species was first recorded by Kofoid and Michener (1911) at Station 4737 of the Expedition. Later Jörgensen (1923) found it in the Bay of Cadiz and in the Ionian Sea. Pavillard (1916) reported it from the Gulf of Lyons under the name of *Phalacroma hindmarchii*.

This is a eupelagic, stenothermal, and warm-water species. Presumably it is widely distributed in tropical and subtropical seas, and it occurs only occasionally in warm-temperate regions. According to the Expedition records, it is found in waters of very high average temperature (80.2°). Most of the record stations are in the warm Mexican Current, and in the western portion of the South Equatorial Drift, and only one is located in the relatively cooler Peruvian Current. Another outstanding peculiarity in the occurrence of this species, according to the Expedition data, is the exceptionally high percentage (50%) of surface records. In no other species of this genus has such a high percentage been recorded.

Phalacroma hindmarchi Murray and Whitting

Figure 18, 19

Phalacroma hindmarchii Murray & Whitting, 1899, p. 330, tab. 4, 5, 6, 8, 9, pl. 31, fig. 5. Lemmermann, 1899a, p. 372; 1901a, p. 372. Cleve, 1901c, p. 271; 1902b, p. 36. Jörgensen, 1923, p. 15, 16. Pavillard, 1923a, p. 879 (*non* 1916, p. 53).
Phalacroma hindmarchi Stüwe, 1909, p. 254, 288.

Diagnosis: — Body of inverted fig-shape in lateral view; epitheca broadly and more or less strongly convex; posterior portion of hypotheca constricted, mammilliform; ventral margin sigmoid, convex anteriorly, concave posteriorly; deepest at or somewhat behind girdle; length: depth, 1.15–1.31: 1; longitudinal axis usually perpendicular to girdle. Dorsoventral and lateral views almost similar. Posterior cingular list 0.27–0.44 the length of body from apex. Cingular lists possibly without structure. Left sulcal list 0.33–0.50 the length of body; distance from R_1 to R_3 is 0.24–0.33 the length of body; R_2 is 0.09–0.16, and R_3 is 0.20–0.25 the greatest depth of body; margin forms angle of 70°–100° at R_3; R_3 inclined posteriorly at 15°–35°; often club-shaped; sometimes reticulate. Theca finely and closely areolate. Length, 82–98 μ.

Probably widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is of inverted fig-shape in lateral view, with broadly and more or less strongly convex epitheca, with the posterior portion of the hypotheca constricted and mammilliform, with the ventral margin of the hypotheca sigmoid, convex anteriorly and concave posteriorly, and with the greatest depth at or somewhat behind the girdle. The ratio between the length and the depth of the body is 1.25 (1.15–1.31): 1. The longitudinal axis usually is about perpendicular to the girdle, but sometimes it is slightly deflected posterodorsally or posteroventrally.

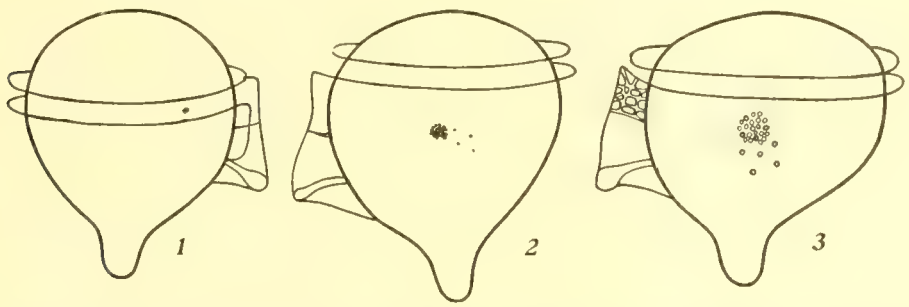

FIGURE 18.— *Phalacroma hindmarchi* Murray and Whitting. 1, right lateral view. 2, 3, left lateral view; surface markings, areolation, and porulation indicated only on small portion of theca in 2, 3. × 430. 1, from Station 4737 (150–0 fathoms). 2, 3, from Station 4730 (300–0 fathoms).

The epitheca is about as deep as the hypotheca or somewhat less, broadly and more or less strongly convex, often dome-shaped, highest in or near the center, and moderately elevated or generally very prominent above the anterior cingular list. The transverse furrow is nearly flat or slightly convex, and its width is 0.20–0.40 the greatest height of the epitheca. The posterior cingular list is 0.38 (0.27–0.44) the length of the body from the apex. The hypotheca sometimes is almost symmetrical, as in the type specimen and in Figure 18: 1; sometimes its dorsal and ventral margins, which are sigmoid, convex anteriorly and concave posteriorly, are more or less different (Figure 18: 3). The posterior portion of the hypotheca is constricted and mammilliform; in none of the Expedition specimens was this constriction quite so pronounced as in the type (Murray and Whitting, 1899, pl. 31, fig. 5). The antapex is narrowly rounded to subacute. In dorsoventral view the body has about the same shape as in lateral view, with the exception that it is somewhat narrower.

The cingular lists are subhorizontal, subequal, and about as wide as the transverse furrow; judging by the figures of the type and by Figures 18, 19, these lists are hyaline and without structure. The sulcus is about 0.4 the length of the hypotheca. The right sulcal list extends to the posterior main rib of the left

sulcal list, is of subequal width throughout the greater part of its length, as wide as or somewhat narrower than the transverse furrow, and rounded posteriorly. The left sulcal list is of moderate size. Its length is 0.33–0.50 the length of the body, and the distance between the anterior and posterior main ribs is 0.24–0.33 the length of the body. It ends somewhat in front of the base of the posterior mammilliform projection of the body. The anterior main rib, when present, is 0.07–0.14, the fission rib 0.09–0.16, and the posterior main rib 0.20–0.25 the greatest depth of the body; behind the posterior main rib the list decreases suddenly in width. Between the anterior and posterior main ribs, the free margin of this list is almost straight, gently convex or concave, sigmoid, *i.e.*, concave anteriorly and convex posteriorly, or it is somewhat irregular; at the posterior main rib it forms an angle of 70°–100°; behind the last-mentioned rib it is either straight or gently concave or convex. The anterior main rib and the fission rib of this list are of moderate strength or rather weak; the posterior main rib usually is quite heavy and club-shaped distally; all of them are straight or almost so, or the posterior has a gentle posterior concavity. The distance between the anterior main rib and the fission rib is about 0.33–0.50 the distance from the anterior to the posterior main rib. The posterior main rib has a posterior inclination of 15°–35°.

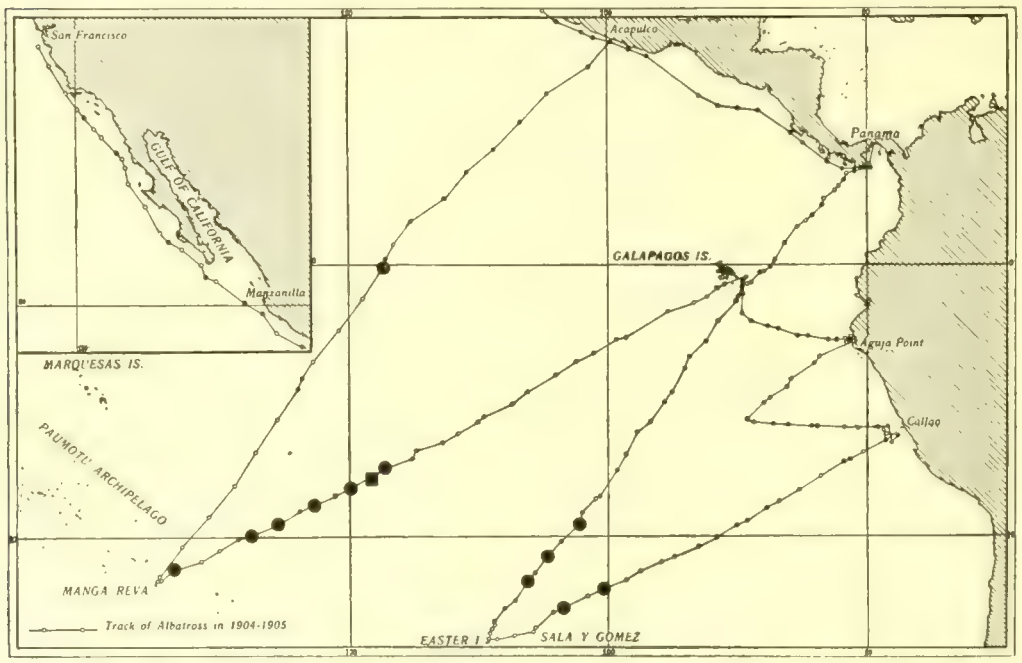

FIGURE 19. — Occurrence of *Phalacroma hindmarchi* Murray and Whitting. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

Besides the main ribs, this list sometimes has a well-developed reticulation (Figure 18: 3). There are no accessory lists or sails.

The thecal wall has a fairly great number of scattered pores, interspersed with more numerous, small, rounded, and closely set areoles of somewhat varying size (Figure 18: 2, 3). Usually the areoles are of about the same size as the pores, but sometimes they are smaller (see Cleve, 1901c, p. 271).

Megacytic stages were found.

The proportions of five of the Expedition specimens and of the type specimen as represented by Murray and Whitting (1899) were measured.

Dimensions: — Length of body, 82–98 μ (average, 87 μ). Greatest depth of body, 65–75 μ (average, 69.5 μ). The type specimen as represented by Murray and Whitting (1899, pl. 31, fig. 5) was about 92 μ long and 75 μ deep.

Variations: — The length of the body, the relative height of the epitheca, the degree of symmetry and of posterior constriction of the hypotheca, and the structure of the theca and of the left sulcal list appear to be the most variable characters.

Comparisons: — Most of the Expedition specimens referred to *Phalacroma hindmarchi* (Figure 18: 1) agree closely with the type as figured by Murray and Whitting (1899, pl. 31, fig. 5). Others are more or less aberrant (Figure 18: 2, 3), but even in their case the assignment may be regarded as certain.

Phalacroma hindmarchi is closely related to *P. favus*, *P. rapa*, *P. mitra*, and *P. dolichopterygium*, although this relationship appears to be collateral rather than linear. In other words, *P. hindmarchi* seems to be a highly differentiated member of an evolutionary branch originating from the same ancestral form as the branch represented by the last four species and partly embodying the same tendencies as the latter branch, *e.g.*, the tendency to constrict the posterior portion of the hypotheca into a mammilliform projection. *Phalacroma hindmarchi* is easily distinguished from *P. favus*, *P. rapa*, *P. mitra*, and *P. dolichopterygium* by its higher and more dome-shaped epitheca, and by having its thecal wall finely areolated instead of reticulated.

According to Murray and Whitting (1899, p. 330), *Phalacroma hindmarchi* is "closely allied to *P. operculatum*." However, this relationship is not so evident as the ones suggested above.

Occurrence: — *Phalacroma hindmarchi* is recorded at thirteen of the 127 stations. There are 0, 0, 2, 3, 7, and 1 stations on the six lines of the Expedition. Of these thirteen stations, four (4689, 4691, 4697, 4699) are in the Easter Island Eddy; eight (4701, 4730, 4731, 4732, 4734, 4736, 4737, 4739) are in the South

Equatorial Drift; one (4742) is in the South Equatorial Current. At one of these stations (4731) the species is recorded from the surface; at one station (4737) from 100–0 fathoms as well as from 300–0 fathoms. The remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these thirteen stations at the surface was 72.0°–81.5°; the average was 77.2°. At Station 4731, the only surface record, the surface temperature was 79.5°.

At four stations (4689, 4731, 4734, 4739) the frequency is 1%; in the remaining cases it is less.

The species was first recorded by Murray and Whitting (1899), who found it at nine stations in the tropical and subtropical regions of the Atlantic, between lat. 14° N. and 31° N., and in the Caribbean Sea. Later Cleve (1901c, 1902b) reported it from the Atlantic, between lat. 9° N. and 34° N., and from the Caribbean Sea; and Stüwe (1909) from the Atlantic, at lat. 3° 50′ N., long. 26° 15′ W. (South Equatorial Current).

According to these authors, this species occurs in waters of the following temperatures and salinities.

	Temperature	Range	Number and Mean of Observations		Salinity	Range	Number and Mean of Observations	
Murray and Whitting (1899)	67°–69°							
Cleve (1901c)		70.0°–82.0°	16	75.5°		34.88–37.43	10	36.27
Cleve (1902b)	76.3°				37.17			
Stüwe (1909)	80.2°							

Of the authors who have contributed toward a knowledge of the distribution of this species only Murray and Whitting (1899) give any descriptions or figures by means of which their determinations may be checked.

Jörgensen (1923, p. 16) writes as follows: "I have not noticed that the species I have noted from the cruise of the Thor as *Ph. Hindmarchii* . . ." However, *P. hindmarchi* is not mentioned by this author except in connection with the discussion of *P. favus*. The statement quoted above therefore is either due to a *lapsus pennae*, or the account of *P. hindmarchi* was overlooked.

This species is eupelagic and widely distributed, but rare, in tropical, subtropical, and warm-temperate seas. Its distribution in the Eastern Pacific, according to the Expedition data, is remarkably similar to that of *Amphisolenia schauinslandi* and *A. thrinax* (see p. 442). Although there are as many as thirteen record stations, the species was never found in the California Current, Mexican Current, Panamic Area, and Peruvian Current. With one exception, all the record stations are in or near the Easter Island Eddy and in the western portion of the South Equatorial Drift. The average temperature of its habitat is high, 77.2.°

6. Expulsum Group. Both the species referred to this group, *Phalacroma protuberans* and *P. expulsum*, were found in the material of the Expedition.

Phalacroma protuberans, sp. nov.

Figure 20: 6–9

Diagnosis: — Body subovate to subcircular in lateral outline, with dorsal shoulder-like constriction at posterior cingular list, deepest in or somewhat in front of the middle, and 1.08–1.18 times longer than deep; longitudinal axis perpendicular to girdle or deflected posteroventrally at 1°–4°. In dorsal view wedge-shaped, widest just behind girdle, subacute to narrowly rounded posteriorly, and with more or less pronounced rounded protuberances just behind girdle; length: width, 1.38–1.74: 1. Posterior cingular list 0.23–0.26 the length of body from apex. Cingular lists 1.7–2.0 the width of transverse furrow; their structure unknown. Left sulcal list 0.64–0.65 the length of body; R_1 is 0.18–0.20, R_2 is 0.14–0.16 the greatest depth of body; R_3 absent; margin rounded or rounded angular posteriorly. Length, 53.0–59.6 μ.

Eastern tropical Pacific.

Description: — A medium-sized species, the body of which is subovate to subcircular in lateral outline, with a dorsal shoulder-like constriction at the posterior cingular list, and deepest in or somewhat in front of the middle. The ratio between the length and the depth of the body is 1.13 (1.08–1.18): 1. The longitudinal axis is perpendicular to the girdle, or it has a posteroventral deflection of 1°–4°.

The epitheca is 0.74 (0.71–0.76) as deep as the hypotheca, highest in the center, of moderate convexity or more or less flat, and moderately to rather slightly elevated above the anterior cingular list. The transverse furrow is somewhat concave, and about as wide as or somewhat narrower than the greatest height of the epitheca. The posterior cingular list is 0.25 (0.23–0.26) the length of the body from the apex. The hypotheca sometimes is subsymmetrical (Figure 20: 6), sometimes it is decidedly flatter ventrally than dorsally (Figure 20: 8). The dorsal margin is subuniformly, and gently to moderately convex except just behind the girdle where it is more bulging. The ventral margin, from the girdle to the posterior end of the left sulcal list, is gently convex. The postmargin is moderately to rather strongly convex and confluent with the dorsal and ventral margins. In dorsoventral view the body is wedge-shaped, widest just behind the girdle, subacute to narrowly rounded posteriorly, and with broadly rounded, more or less prominent protuberances just behind the girdle, one on each side of

the body; the ratio between the length and the width of the body is 1.56 (1.38–1.74):1.

The cingular lists are subhorizontal and subequal; their width is about 1.7–2.3 the width of the transverse furrow and 0.23–0.26 the greatest depth of the body; their structure is unknown. The right sulcal list is unusually short, extending to or slightly beyond the fission rib of the left sulcal list, and subtriangular, decreasing gradually in width posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is about 0.64 0.65 the length of the body and of subuniform width throughout the greater portion of its length. The anterior main rib is 0.18–0.20, the fission rib 0.14–0.16 the greatest depth of the body. The posterior main rib is lacking. The anterior two thirds of the free

FIGURE 20.— 1–5, *Phalacroma expulsum* (Kofoid and Michener). 1, in left lateral view; 2, 4, in dorsal view; 3, in right lateral view; 5, in ventral view. 2, from the same specimen as 1; 4, from the same specimen as 3. 1–3, ×430; 4, of unknown magnification; 5, × 890. 1, 2, from Station 4713 (300–0 fathoms); 3, 4, from Station 4724 (300–0 fathoms); 5, from Station 4717 (300–0 fathoms). 6–9, *Phalacroma protuberans*, sp. nov. 6, 8, in right lateral view; 7, 9, in dorsal view. 7, from the same specimen as 6; 8, 9, from type specimen. Porulation of theca indicated only in 8. × 430. Station 4730 (300–0 fathoms).

margin of this list is almost straight, or gently sigmoid, concave anteriorly and convex posteriorly. The posterior portion of this margin, which is confluent with the anterior, is gently convex (Figure 20:6) to rounded angular (Figure 20:8). The main ribs are straight or almost so, and not club-shaped or otherwise modified. There are no accessory lists or sails. The thecal wall is porulate.

Megacytic specimens were not recorded.

The dimensions of two specimens were measured.

Dimensions: — Length of body, 53.0–59.6 μ (type, 59.6 μ). Greatest depth of body, 44.9–55.2 μ (type, 55.2 μ).

Variations: — The two specimens differ strikingly from each other in the depth of the body, in the width and shape of the left sulcal list, in the development

of the lateral expansions and constrictions of the body, and in the width of the posterior end of the body when seen in dorsoventral view. Figure 20:6 may, however, represent a specimen drawn in a somewhat tilted position.

Comparisons: — *Phalacroma protuberans* is established on four outline drawings made from the two Expedition specimens. The structure of the cingular and sulcal lists and of the thecal wall is unknown.

In spite of several rather striking differences, this species probably is closely related to *Phalacroma expulsum*. It differs most strikingly from this species in the less-developed posteroventral inclination of the longitudinal axis of the body, in the greater width and subhorizontal position of the cingular lists, in the greater length of the left sulcal list, and in having a pair of broadly rounded lateral protuberances just behind the girdle. For further discussion on the relationships of these two species, see *P. expulsum* (p. 159).

Occurrence: — *Phalacroma protuberans* is recorded at only one (4730, type locality) of the 127 stations, on the fifth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, and at a surface temperature of 79°. The frequency is less than 1% (two specimens).

Phalacroma expulsum (Kofoid and Michener)

Plate 5, fig. 1. Figure 20: 1–5

Dinophysis expulsa Kofoid & Michener, 1911, p. 268.
Phalacroma stenopterygium Jörgensen, 1923, p. 11, 24, 44, fig. 10.

Diagnosis: — Body sack-like in lateral outline, truncate anteriorly, with dorsal shoulder-like constriction at girdle, broadly rounded posteriorly, deepest in the middle, and 1.02–1.24 times longer than deep; longitudinal axis deflected posteroventrally at 5°–15°. In dorsal view wedge-shaped, widest at posterior cingular list or in the middle, subacute to narrowly rounded posteriorly, and with broad constriction in front of the middle; length: width, 1.42–1.82: 1. Posterior cingular list 0.11–0.17 the length of body from apex; epitheca barely if at all visible above anterior cingular list. Cingular lists inclined anteriorly at 30°–45°, with or without ribs; the anterior about as wide as or somewhat narrower than transverse furrow; the posterior narrower than the anterior. Left sulcal list 0.42–0.57 the length of body; R_1 is 0.12–0.16, R_2 is 0.09–0.17 the greatest depth of body; R_3 absent; margin rounded, not angular, posteriorly. Theca centrally faintly reticulate; about 17–20 polygons border girdle posteriorly. Length, 53.7–67.5 μ.

Probably widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is sack-like in lateral outline, truncate anteriorly, with dorsal shoulder-like constriction at girdle, broadly rounded posteriorly, and deepest in or near the middle. The ratio between the length and the depth of the body is 1.02–1.24: 1; in the Expedition specimens this ratio is 1.15 (1.08–1.24): 1; in Jörgensen's (1923) it varied between 1.02: 1 and 1.23: 1. The longitudinal axis is inclined posteroventrally at 5°–15°; in the Expedition specimens this angle is 8° (5°–10°), in that figured by Jörgensen (1923, fig. 10) it is 15°.

The epitheca is 0.60 (0.54–0.66) as deep as the hypotheca, gently convex or flat, highest in or ventrally to the center, and barely if at all visible above the anterior cingular list. The transverse furrow is somewhat concave, and about as wide as or somewhat wider than the greatest height of the epitheca. The posterior cingular list is 0.15 (0.11–0.17) the length of the body from the apex. The hypotheca is more or less inclined posteroventrally (see above). The dorsal margin is subuniformly and gently to moderately convex. The ventral margin, from the girdle to the posterior end of the left sulcal list, is almost straight or gently concave or convex. The postmargin is subuniformly and broadly rounded, subsemicircular, and either confluent with the dorsal and ventral margins, or (Jörgensen, 1923, fig. 10) forming a distinct although well-rounded angle at the posterior end of the left sulcal list. In dorsoventral view the body is wedge-shaped, widest at the posterior cingular list or in the middle, and subacute to narrowly rounded posteriorly; between the middle, where the body is more or less expanded, and the posterior cingular list, there is a broad and more or less pronounced constriction; the ratio between the length and the width is 1.60 (1.42–1.82): 1.

The cingular lists, which are characterized by an anterior inclination of 30°–45°, usually are subequal, but sometimes the posterior is more or less strikingly narrower than the anterior. The anterior is about as wide as or somewhat narrower than the transverse furrow and about 0.11 (0.09–0.13) the greatest depth of the body. In the specimens examined both these lists are hyaline and lack distinct ribs. Jörgensen (1923, p. 11), on the other hand, writes about these lists: "both without or with distinct short radial transverse ribs, innermost by the cell." The right sulcal list is unusually short and extends to or slightly beyond the fission rib of the left sulcal list; it is subtriangular, or rounded anteriorly, and decreases gradually in width posteriorly; its maximum width does not exceed the width of the transverse furrow. The left sulcal list is 0.51 (0.42–0.57) the length of the body, and of subuniform width throughout the greater part of its length.

The anterior main rib is 0.13 (0.12–0.16) and the fission rib 0.13 (0.09–0.17) the greatest depth of the body. The posterior main rib is usually lacking, but sometimes a short rudiment may be found (Jörgensen, 1923, p. 11). The anterior half of the free margin of this list is straight or gently concave or convex; the posterior half, which is confluent with the anterior, is gently, moderately, or strongly convex, and not angular as in most species of the genus. The main ribs are straight or almost so, and not club-shaped or otherwise modified. With the exception of the main ribs, this list appears always to lack structural differentiation. There are no accessory lists or sails.

Except along the dorsal, posterior, and ventral margins, the thecal wall of the hypotheca has a fine reticulum of polygonate meshes; the posterior margin of the girdle is bordered by seventeen to twenty polygons. Sometimes the polygons are subequal in size, sometimes they decrease somewhat in size posteriorly. In the transverse furrow there are two rows of polygons of about the same average size as the hypothecal polygons. On the epitheca no reticulation has been observed. The whole theca is furnished with evenly scattered pores. In the transverse furrow every polygon has a pore, which usually is located in or near the center.

Megacytic stages were not recorded.

The dimensions of six of the Expedition specimens and of the specimen figured by Jörgensen (1923, fig. 10) were measured.

Dimensions: — Length of body, 53.7–64.5 μ (average, 58.3 μ; type, 55.8 μ). Greatest depth of body, 45.7–51.2 μ (average, 49.1 μ; type, 47.8 μ). The specimens measured by Jörgensen (1923) were, according to a statement in the text, 54–63 μ long and 53–58 μ deep; the one figured (1923, fig. 10) was 67.5 μ long and 55.0 μ deep.

Variations: — *Phalacroma expulsum* is rather variable. The following characters are the most variable: — the size of the body, the relative depth and width of the body, the degree of the posteroventral inclination of the longitudinal axis, the relative depth of the epitheca, the shape of the ventral margin of the hypotheca, the development of the lateral expansions and constrictions of the body, and the width of the posterior end of the body when seen in dorsoventral view.

Comparisons: — The description and figures of this species are based on the type material. The most aberrant specimen is represented by Figure 20:3, 4. It differs from the remaining specimens in its narrower body, in the subuniform convexity of the ventral margin of its body from the girdle to the antapex, and in the shortness of its left sulcal list. Its present assignment is tentative. It has

been referred here mainly because of the fact that its body, in dorsoventral view, has an outline of about the same shape as that of the typical specimens.

The specimen figured by Jörgensen (1923, fig. 10) as *Phalacroma stenopterygium* differs from the typical representatives mainly in the following respects: its longitudinal axis has a more pronounced posteroventral inclination (15°, as compared with 5°–10°), the ventral margin of its body forms a distinct, although rounded corner at the posterior end of the left sulcal list, and its posterior cingular list is decidedly narrower. Jörgensen (1923) states that his specimens were 54–63 μ long and 53–58 μ deep. From this it is evident that at least some of his specimens were decidedly deeper relatively than any of the Expedition specimens.

The generic assignment of this species is somewhat uncertain. Kofoid and Michener (1911) allocated it to Dinophysis on account of the narrowness of the epitheca, the shape of the hypotheca in lateral view, and the position and anterior inclination of the cingular list. Jörgensen (1923, p. 11), on the other hand, writes that: "Despite the great resemblance to the Dinophysis species, I have ascribed it to the genus Phalacroma, chiefly on account of the wedge-shaped cell and also because the lower girdle list can apparently have the same short radial ribs as the upper." With regard to the last-mentioned character it should be pointed out, first, that in the specimens examined both the cingular lists lacked ribs; and, second, that even though the ribbing of the posterior cingular list is a character frequently found in the species of Phalacroma, nevertheless, it is not limited to this genus but is found also in typical representatives of Dinophysis; see *Dinophysis triacantha*, Figure 42:2. Furthermore, *Dinophysis cuneiformis*, which is a typical representative of its genus, is narrowly wedge-shaped in dorsoventral view (Meunier, 1910, pl. 14, fig. 32). However, Jörgensen's (1923) decision is accepted by the close agreement between the dorsoventral outline of the body in this species and in some species of Phalacroma, *e.g.*, in *Phalacroma favus* (Figure 14:2); by the regularly ovate, ellipsoidal, or bilaterally flattened dorsoventral outline of almost all the other known species of Dinophysis; and by the fact that in the closely related *Phalacroma protuberans* the epitheca is rather large and the cingular lists are subhorizontal. Of course, the question is of minor importance, since the genera Dinophysis and Phalacroma are so closely related that their separation is almost arbitrary.

The structurally closest-known relative of *Phalacroma expulsum* is *P. protuberans*. The former species differs most strikingly from the latter in the more pronounced posteroventral inclination of the longitudinal axis of the body, in the anterior inclination of the cingular lists, and in the relative shortness of the left

sulcal list. These two species occupy structurally a rather isolated position and ought to be made the only representatives of a special group. Jörgensen (1923) assigned *P. expulsum* to the CUNEUS group. This allocation undoubtedly was made on account of the wedge-like shape of the body in dorsoventral view and because of the fact that the free margin of the left sulcal list is rounded posteroventrally, instead of angular as in most of the species of Phalacroma. However, this allocation greatly decreases the structural uniformity of the CUNEUS group, and for that reason should not be maintained. Note, for instance, the relative narrowness of the epitheca and the sack-like, instead of wedge-like, shape of the hypotheca of *P. expulsum* in lateral view. On the other hand, these two species show distinct affiliation to the CUNEUS group and should thus be placed near to it. Jörgensen (1923, p. 11) also points out that *P. expulsum* "in several respects, especially in the left longitudinal furrow list," is "remarkably like" *Dinophysis sphaerica* (= *similis*). However, the relationship between these two species must be regarded as uncertain; the similarities in the shape of the hypotheca in lateral view and in the shape of the left sulcal list are rather superficial, while the difference in the shape of the body in dorsoventral view is profound. It also may be worth mentioning that *Dinophysis okamurai* (Figure 31: 5) shows a certain resemblance to *Phalacroma expulsum* in the shape of the body in lateral view.

Occurrence: — *Phalacroma expulsum* is recorded at four of the 127 stations. There are 0, 0, 0, 1, 3, and 0 stations on the six lines of the Expedition. Of these four stations, one (4713) is in the Galapagos Eddy, and three (4717, 4720, 4724) are in the South Equatorial Drift. There is one record from a surface haul (4720, from Salpa stomach). The remaining records refer to hauls from 300–0 fathoms.

The temperature range of these four stations at the surface was 73°–81°, and the average was 76.8°. At Station 4720, where the species was taken at the surface, the surface temperature was 76°.

The frequency is in every case less than 1%.

The species was first recorded by Kofoid and Michener (1911) from Station 4717 of the Expedition, the type locality. Later Jörgensen (1923) reported it to be "scattered throughout the whole of the Mediterranean to the Bay of Corinth, often in deep water samples." It is probably widely distributed in tropical, subtropical, and warm-temperate seas.

7. LIMBATUM GROUP. Three species, viz., *Phalacroma limbatum*, *P. bipartitum*, and *P. pulchrum*, belong to this group, and all of them occurred in the collections of the Expedition.

Phalacroma limbatum Kofoid and Michener

Plate 3, fig. 3–5. Figure 21: 1

Phalacroma limbata Kofoid & Michener, 1911, p. 290.

Diagnosis: — Body subcircular in lateral outline, deepest near the middle; length: depth, 1.08–1.10: 1. In dorsal view lens-shaped, 2.27 times longer than wide, with narrowly rounded apices. Posterior cingular list 0.38–0.50 the length of body from apex. Cingular lists appear to be without ribs. Left sulcal list: distance between R_1 and R_3 is 0.25–0.28 the length of body; R_2 is 0.12–0.14 and R_3 is 0.19–0.24 the greatest depth of body; margin forms angle of 70°–90° at R_3; R_3 inclined posteriorly at 20°–35°. Two parasagittal lists encircle body; the left of subuniform width throughout, and its maximum width is subequal to or somewhat less than width of transverse furrow; the right resembles the left but forms on antapex an acute, wedge-shaped, posterior sail directed posteriorly. Sail 0.15–0.27 the greatest depth of body in length, with central rib, whose proximal half might form more or less complex reticulum; angle at its tip, 35°–50°. Right parasagittal list forms direct continuation of left sulcal list. Central portion of each thecal valve with reticulum of moderate-sized mesh. Length, 68.9–76.5 μ.

Eastern tropical Pacific.

Description: — A medium-sized species, the body of which is subcircular in lateral outline, slightly longer than deep, and deepest near the middle. The ratio between the length and the greatest depth of the body is 1.09 (1.08–1.10): 1. The longitudinal axis is perpendicular to the girdle.

The epitheca is about 0.87 as deep as the hypotheca, strongly and evenly convex, dome-shaped, highest in the center, and very prominent above the anterior cingular list. The transverse furrow is flat, or slightly convex or concave, and its width is 0.24–0.32 the greatest height of the epitheca. The posterior cingular list is 0.38–0.50 the length of the body from the apex. The hypotheca is symmetrical; its dorsal, posterior, and ventral margins are well and evenly convex, and confluent. Its posterior portion is of about the same depth as the anterior portion of the body. In dorsoventral view the body is lens-shaped, about 2.27 times wider than long, widest at the girdle, and with narrowly rounded apices; the side contours are nearly evenly convex.

The cingular lists are subhorizontal and subequal; their width about equals or somewhat exceeds the width of the transverse furrow; and they are without ribs, according to available drawings (see p. 164). The sulcus is about half as long as the hypotheca. The flagellar pore is just behind the junction of the

cingulum and the sulcus. On the ventral side of the left valve a small pore is found near the sagittal suture, just in front of the anterior cingular list. The right sulcal list extends to the posterior main rib of the left sulcal list; it is subtriangular, decreasing gradually in width posteriorly, and anteriorly it is about as wide as the transverse furrow. The left sulcal list is of moderate width and rather short. The distance between the anterior and posterior main ribs is 0.25–0.28 the length of the body. The anterior main rib is 0.13–0.14, the fission rib 0.12–0.14, and the posterior main rib 0.19–0.24 the greatest depth of the body; behind the posterior main rib the list decreases suddenly in width. The free margin of this list is gently sigmoid or nearly straight between the anterior and posterior main ribs; at the posterior main rib it forms an angle of 70°–90°; behind the posterior main rib it is gently concave. The main ribs of this list are of moderate strength and almost straight; or the posterior one is rather strong and gently concave posteriorly; none of them is club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.33–0.50 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 20°–35°. Besides the three main ribs, this list sometimes has a faint reticulation; and just behind the posterior main rib it has a fine rib with a posterior inclination of about 50°–60°. Two parasagittal lists encircle the entire body; the one on the right valve of the hypotheca forms a direct continuation of the left sulcal list. The left parasagittal list is of subuniform width throughout its entire length, has a maximum width subequal to or somewhat less than the width of the transverse furrow, and is furnished with a moderate number of simple, free or anastomosing, incomplete riblets. The right parasagittal list resembles the left, but it forms on the antapex an acute, wedge-shaped posterior sail, directed posteriorly. When fully developed, the sail is 0.15–0.27 the greatest depth of the body in length and has a central rib, whose proximal half might form a more or less complex reticulum; the angle at its tip is 35°–50°.

The central portion of each thecal valve, with the exception of the transverse furrow, is characterized by a reticulum of closely set, rather heavily margined polygons of moderate size. The polygons are subequal, and on each valve about thirty of them border the posterior margin of the transverse furrow. The entire theca is furnished with scattered pores. There is a central pore in most of the polygons; and in the transverse furrow there are three rows of pores, each row with thirty to forty pores on each valve.

Megacytic stages were not found.

The proportions of two specimens were measured.

Dimensions: — Length of body, 68.9–76.5 μ (average, 72.7 μ; type, 76.5 μ). Greatest depth of body, 62.4–70.6 μ (average, 66.5 μ; type, 70.6 μ).

Variations: — This species is fairly constant; the relative height of the epitheca, the width of the parasagittal lists, and the size and structure of the posterior sail of the right parasagittal list are the most variable characters.

Comparisons: — The description and figures are based on the type material.

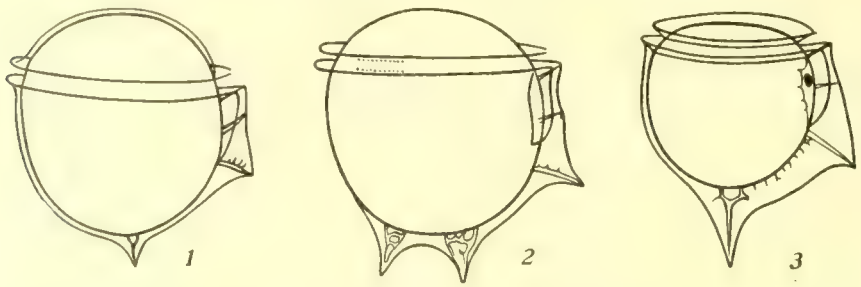

FIGURE 21.— 1, *Phalacroma limbatum* Kofoid and Michener, right lateral view. × 430. Station 4722 (300–0 fathoms). 2, *Phalacroma bipartitum*, sp. nov., right lateral view of type specimen; porulation indicated only on portion of transverse furrow. × 430. Station 4736 (300–0 fathoms). 3, *Phalacroma pulchrum* Kofoid and Michener, right lateral view of type specimen. × 430. Station 4699 (300–0 fathoms).

We refer the specimen, Plate 3, fig. 4, tentatively to this species; the similarities between it and those described above are as follows: — the body is subcircular in lateral outline; the girdle is subequatorial in position; only the central portions of the thecal valves are reticulated; there is an accessory rib in the left sulcal list just behind the posterior main rib. On the other hand, the differences exhibited by the first specimen also are conspicuous; for instance, it lacks parasagittal lists except on the antapical portion of the hypotheca; at the antapex its right parasagittal list is rather wide, but no acute, wedge-shaped projection supported by a central rib is developed. This specimen has been referred to this species, since these differences probably are due to regulatory adjustments following binary fission. However, since the regulatory structural changes that take place at binary fission are unknown, this assignment must be regarded as tentative. The specimen is not included in the description given above, and its locality is omitted from the account of the occurrences. Its length is 84 μ, its greatest depth, 78 μ; its cingular lists are ribbed. It was taken at Station 4687 of the Expedition, in a haul from 300–0 fathoms; surface temperature, 73°.

Phalacroma limbatum is structurally closely related to *P. bipartitum*. These species resemble each other in the following respects: — (*1*) the body is subcircular in lateral view; (*2*) the longitudinal axis of the body is perpendicular to the girdle; (*3*) the epitheca is high; (*4*) the cingular lists are subhorizontal, sub-

equal, and about as wide as the transverse furrow; (*5*) the left sulcal list is angular at the posterior main rib and is continued posteriorly by a parasagittal list that has one or two acute, wedge-shaped posterior sails with a more or less complex reticulum of irregular ribs; (*6*) the central portion of each valve, with the exception of the transverse furrow, has a reticulum of closely placed, rather heavily margined polygons; the polygons are subequal, of moderate size, and most of them have a central pore; in the transverse furrow and near the sagittal margins, the valves are porulate but not reticulate; (*7*) the size of the body is the same. It should be remembered, however, that several of these similarities are due to the fact that these two species in some respects are fairly low in the scale of the evolutionary development of the genus. The subcircular shape of the body in lateral view, the longitudinal axis of the body being perpendicular to the girdle, the relatively great height of the epitheca, the cingular lists being subhorizontal, subequal, and about as wide as the transverse furrow, and the angularity of the left sulcal list at the posterior main rib are more or less primitive characters and, therefore, must be considered to have relatively little importance in an attempt to determine the degree of relationship between these and other more or less primitive species of this genus. *Phalacroma limbatum* is more primitive than *P. bipartitum* in having a relatively higher epitheca, and in the right parasagittal list having one, instead of two, acute triangular posterior sails. On the other hand, it is more advanced than the last species in having the two parasagittal lists encircle the entire body.

Phalacroma limbatum is probably also rather closely related to *P. pulchrum*. This relationship is indicated by the following similarities: — (*1*) the body of these two species is subcircular in lateral view and lens-shaped in dorsoventral view; (*2*) on the hypotheca both have two parasagittal lists; the left parasagittal list is narrow and of subuniform width throughout; the right forms a direct continuation of the left sulcal list and has a large, acute, wedge-shaped posterior sail, which is furnished with a central rib; (*3*) at least in some specimens of *P. pulchrum* (Jörgensen, 1923, fig. 18), the left sulcal list has behind the posterior main rib an accessory rib of the same kind as that found in *P. limbatum*. *Phalacroma limbatum* is more primitive than *P. pulchrum* in having a relatively higher epitheca and subhorizontal cingular lists. It is more advanced in size of body, and in having parasagittal lists on the epitheca.

With regard to the relationship between the species mentioned above and *Dinophysis collaris* (p. 295), see the section on comparisons.

Occurrence: — *Phalacroma limbatum* is recorded at six of the 127 stations.

There are 0, 1, 2, 2, 1, and 0 stations on the six lines of the Expedition. Of these six stations, two (4667, 4676) are in the Peruvian Current; one (4699) is in the Easter Island Eddy; and three (4681, 4705, 4722) are in the South Equatorial Drift. At one station (4681) the species is recorded from 300–0 fathoms and 800–0 fathoms. All the other records refer to hauls from 300–0 fathoms only.

The temperature range of these six stations at the surface was 68°–75°; the average was 71.2°.

At two stations (4676, 4705) the frequency is 1%; at the remaining stations it is less.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) at Station 4667 of the Expedition, which thus is the type locality.

Phalacroma bipartitum, sp. nov.

Figure 21:2

Diagnosis: — Body subcircular in lateral outline, deepest in the middle; length: depth, 1.04:1. Posterior cingular list 0.30 the length of body from apex. Left sulcal list: distance between R_1 and R_3 is 0.41 the length of body; R_2 is 0.13 and R_3 is 0.25 the greatest depth of body; margin acuminate at R_3 at angle of 40°; R_3 inclined posteriorly at 20°. Around posterior portion of hypotheca there is on right valve a parasagittal list forming direct continuation of left sulcal list; parasagittal list forms two subequal, acute, wedge-shaped posterior sails, one on each side of midline, both with irregularly anastomosing ribs; length of sails equals length of R_3; angles at their tips, 30°–40°; width of list between sails and between ventral sail and R_3 is 0.20 the length of R_3. Central portion of each valve reticulated with heavily margined polygons of moderate size. Length, 68 μ.

Eastern tropical Pacific.

Description: — A medium-sized species, the body of which is subcircular in lateral outline, about as long as deep and deepest near the middle. The ratio between the length and the greatest depth of the body is 1.04:1. The longitudinal axis of the body is perpendicular to the girdle.

The epitheca is 0.87 as deep as the hypotheca, strongly and evenly convex, dome-shaped, highest in the center, and very prominent above the anterior cingular list. The transverse furrow is slightly convex; and its width is 0.37 the greatest height of the epitheca. The posterior cingular list is 0.30 the length of the body from the apex. The hypotheca is symmetrical; its dorsal, posterior,

and ventral margins are well and evenly convex, and confluent. In the type specimen the posterior end of the body is slightly narrower than the anterior.

The cingular lists are subhorizontal and subequal; their width about equals the width of the transverse furrow; their structure is unknown. The right sulcal list extends to a point about halfway between the fission rib and the posterior main rib of the left sulcal list; it is of subuniform width throughout the greater part of its length, and its greatest width is somewhat less than the length of the fission rib of the left sulcal list; its free margin is sigmoid, being slightly concave anteriorly and rather strongly convex posteriorly. The left sulcal list is of moderate length and width. The distance between the anterior and posterior main ribs is 0.41 the length of the body. The anterior main rib and the fission rib are subequal and 0.13 the greatest depth of the body; the posterior main rib is 0.25 the greatest depth of the body; behind the posterior main rib the list decreases suddenly in width. The free margin of this list is gently concave between the anterior main rib and the fission rib as well as between the fission rib and the posterior main rib; at the posterior main rib it is acuminate and forms an angle of about 40°; behind the posterior main rib it is gently concave. The main ribs of this list are of moderate strength and almost straight, and none of them is club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is about 0.50 the distance from the anterior to the posterior main rib. The posterior main rib has a posterior inclination of about 20°. There are no ribs except the three main ribs, but, judging by the short projections from the anterior side of the posterior main rib in the drawing of the type specimen (Figure 21:2), this list probably has a faint reticulation. On the right valve there is a parasagittal list, which forms a direct continuation of the left sulcal list, runs around the posterior portion of the hypotheca and extends to the posterior end of the dorsal margin of the hypotheca. The parasagittal list is characterized by two subequal, acute, wedge-shaped posterior sails, one on either side of the midline, and both furnished with irregularly anastomosing ribs. The length of these sails about equals the length of the posterior main rib of the left sulcal list; and the angles at their tips are about 30°–40°. The width of the parasagittal list, between the left sulcal list and the ventral sail and between the two sails, is about 0.20 the length of the posterior main rib of the left sulcal list. It is not known whether there is any parasagittal list on the left valve of the hypotheca; nor whether the parasagittal list of the right valve ever extends farther on the dorsal side than in Figure 21:2 (as in the closely related *Phalacroma limbatum*). The epitheca had no parasagittal lists in the type specimen.

The structure of the theca is about the same as in *Phalacroma limbatum; i.e.*, the central portion of each valve, with the exception of the transverse furrow, has a reticulum of closely placed, rather heavily margined polygons. The polygons are subequal and of moderate size, and most of them have a central pore; on each valve about thirty polygons border the posterior side of the transverse furrow. In the transverse furrow and near the sagittal margins the valves are porulate, but not reticulate. In the transverse furrow there are two transverse rows of fine pores, on each valve about forty to fifty pores in each row.

Megacytic stages were not found.

The proportions of the type specimen were measured.

Dimensions: — Length of body, 68.0 μ. Greatest depth of body, 65.5 μ.

Comparisons: — The description of the type is incomplete in some respects; *e.g.*, the shape of the body in dorsoventral view and the structure of the cingular lists are unknown; and the number and the extension of the parasagittal lists are uncertain.

The structurally closest-known relative of *Phalacroma bipartitum* is *P. limbatum* (see p. 164). The former is more advanced than the latter in having a relatively lower epitheca and in having a parasagittal list with two, instead of one, acute, triangular posterior sails. It is more primitive in having the parasagittal list of the hypotheca relatively shorter and in lacking parasagittal lists on the epitheca. It should be noted, however, that the extension of the parasagittal list of the hypotheca presumably is variable (see *Dinophysis collaris*, p. 295).

Phalacroma bipartitum resembles *Dinophysis collaris* in having the parasagittal list of the right valve furnished with two subequal and triangular posterior sails. Whether or not this similarity is an indication of a close relationship cannot be decided. *Dinophysis collaris* is more advanced than *Phalacroma bipartitum* in the rather irregular shape of its body in lateral view, in the reduced height of its epitheca, and in its larger and more differentiated cingular and sulcal lists.

Occurrence: — This species is recorded at only one (4736, the type locality) of the 127 stations, on the fifth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, and at a surface temperature of 81°. The frequency is less than 1% (one specimen).

Phalacroma pulchrum Kofoid and Michener

Plate 3, fig. 1, 6. Figure 21:3

Phalacroma pulchra Kofoid & Michener, *partim*, 1911, p. 290, 291.
Phalacroma circumsutum Jörgensen, *partim*, 1923, p. 17, 43, fig. 18.
Phalacroma pulchrum Jörgensen, 1923, p. 18.

Diagnosis: — Body subcircular in lateral outline, subtruncate anteriorly, deepest near the middle; length: depth, 0.99–1.03:1. In dorsal view narrowly obovate, 1.80 times longer than wide. Posterior cingular list 0.19–0.24 the length of body from apex; epitheca sometimes hardly visible above anterior cingular list. Cingular lists somewhat inclined anteriorly, without ribs. Left sulcal list: distance between R_1 and R_3 is 0.41–0.43 the length of body; R_2 is 0.14–0.16, and R_3 is 0.33–0.38 the greatest depth of body; margin forms angle of 50°–60° at R_3; R_3 inclined posteriorly at 35°–40°. Two parasagittal lists on hypotheca; the left very narrow, sometimes possibly absent. The right continues left sulcal list; dorsally its maximum width is subequal to or less than half the width of transverse furrow; on antapex it forms an acute, wedge-shaped posterior sail directed posteriorly. Sail, when fully developed, 0.33–0.43 the greatest depth of body in length, with central rib whose base might be divided; angle at tip, 30°–40°. Ventrally to sail, width of list is 0.50–1.75 the width of transverse furrow; with about 8–11 short riblets. Theca with fine reticulation. Length, 51.2–52.5 μ.

Tropical, subtropical, and warm-temperate seas.

Description: — A rather small species, the body of which is subcircular in lateral outline, subtruncate anteriorly, and deepest near the middle. The ratio between the length and the greatest depth of the body is 0.99–1.03: 1. The longitudinal axis is perpendicular to the girdle.

The epitheca is 0.77–0.80 as deep as the hypotheca, highest in the center, of moderate convexity to rather flat, and but slightly elevated above the anterior cingular list. The transverse furrow is flat, or slightly convex to concave, and its width is 0.8–2.0 the greatest height of the epitheca. The posterior cingular list is 0.19–0.24 the length of the body from the apex. The hypotheca is almost symmetrical; sometimes, as in the type specimen, it is subcircular, with confluent dorsal, posterior, and ventral margins; sometimes, as in the specimen figured by Jörgensen (1923, fig. 18), its ventral margin is flattened, and its postmargin forms a broadly rounded, subrectangular corner. In dorsoventral view the body is narrowly obovate, about 1.80 times longer than wide, widest somewhat in front of the middle, somewhat more broadly rounded anteriorly than posteriorly, narrowly rounded posteriorly, and with evenly convex side contours.

The cingular lists have an anterior inclination of 20°–40°; the anterior is about as wide as the transverse furrow, the posterior often is slightly narrower. The sulcus is about half as long as the hypotheca. The flagellar pore is located at a distance about equaling its own diameter behind the junction of the cingulum and the sulcus. On the ventral side of the left valve a small pore is found near the

sagittal suture, just in front of the anterior cingular list. The right sulcal list sometimes ends at or somewhat behind a point midway between the fission rib and the posterior main rib of the left sulcal list; sometimes it extends even to the last-mentioned rib; its anterior half is about as wide as the transverse furrow; posteriorly it decreases gradually in width. The left sulcal list is rather large; the distance between its anterior and posterior main ribs is 0.41–0.43 the length of the body. The anterior main rib is 0.14–0.15, the fission rib 0.14–0.16, and the posterior main rib 0.33–0.38 the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list either is nearly straight or slightly sigmoid; in the latter case it is slightly concave anteriorly and convex posteriorly, or *vice versa;* at the posterior main rib it is somewhat acuminate and forms an angle of 50°–60°; behind the last-mentioned rib it is gently concave. The main ribs of this list are of moderate strength and straight or almost so; none of them is club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.33–0.37 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 35°–40°. Somewhat behind the posterior main rib there is in some specimens (Jörgensen, 1923, fig. 18) a fine rib with a posterior inclination of about 75°. Except the ribs mentioned above, the left sulcal list lacks structural differentiations. There are two parasagittal lists on the hypotheca, but none on the epitheca. The left one of these two lists extends, on the dorsal side of the body, from the posterior cingular list to the antapex; it is very narrow, of subuniform width throughout its entire length, and furnished with a few cross-ribs; its maximum width is less than half the width of the transverse furrow; in some specimens (Jörgensen, 1923, fig. 18) it may be absent. The right parasagittal list forms a direct continuation of the left sulcal list; sometimes, as in the type specimen, it extends to the posterior cingular list; sometimes, as in the specimen figured by Jörgensen (1923, fig. 18), it is not developed on the dorsal side of the hypotheca. On the dorsal side this list is narrow, about as wide as or slightly wider than, the left list, of subuniform width throughout, and furnished with a few cross-ribs; posteriorly it forms an acute, wedge-shaped posterior sail directed posteriorly. The sail, when fully developed, is 0.33–0.43 the greatest depth of the body in length, and has a central rib which arises from the antapex, and whose base might be divided; the angle at its tip is 30°–40°. Between this rib and the posterior main rib of the left sulcal list, the right parasagittal list has a minimum width equaling 0.50–1. 75 the width of the transverse furrow, and its margin is evenly concave, or slightly undulating

as in the type specimen; along the base of this portion of the list there are 8–11 short, nearly equidistant, simple or bifurcate riblets; see also the accessory rib of the left sulcal list.

The thecal wall is finely reticulate (Jörgensen, 1923, fig. 18) and furnished with scattered pores. Sometimes the reticulation is so faint as to make it difficult to detect.

Megacytic stages were not recorded.

The dimensions of the type and of the specimen figured by Jörgensen (1923, fig. 18) were measured.

Dimensions: — Length of body, 51.2 μ. Greatest depth of body, 51.6 μ. Specimen figured by Jörgensen (1923, fig. 18): Length of body, 52.5 μ. Greatest depth of body, 51.0 μ.

Variations: — Very little is known about the variability of this species. The specimen figured by Jörgensen (1923) is somewhat more pointed posteriorly than the type specimen, and its right sulcal list is somewhat smaller. The structure of the thecal wall is sometimes fairly well developed, sometimes almost invisible.

Comparisons: — The description and figures are based on the type material.

The structurally closest-known relative of *Phalacroma pulchrum* is *P. limbatum*. The former can easily be distinguished by its low epitheca and by the absence of parasagittal lists from the epitheca (see *P. limbatum*, p. 164).

Synonymy: — Some of the specimens on which Kofoid and Michener (1911) based their description, have in the present paper been referred to *P. cuneolus*, sp. nov. *Phalacroma circumsutum* Jörgensen (1923) includes *P. circumsutum* Karsten and *P. pulchrum* Kofoid and Michener.

Occurrence: — *Phalacroma pulchrum* is recorded at six of the 127 stations. There are 0, 0, 0, 4, 1, and 1 stations on the six lines of the Expedition. Of these six stations, one (4699) is in the Easter Island Eddy; one (4713) is in the Galapagos Eddy; four (4701, 4705, 4730, 4740) are in the South Equatorial Drift. All the records refer to hauls from 300–0 fathoms.

The temperature range of these six stations at the surface was 72°–81°; the average was 75.9°.

The frequency is less than 1 % in all the cases recorded.

The species was first recorded by Kofoid and Michener (1911) at Station 4699, the type locality. Later Jörgensen (1923) found it in the Mediterranean, the Thor Expedition, and possibly also in the Guinea Current, the German South Pole Expedition.

This is a eupelagic species widely distributed in tropical, subtropical, and warm-temperate seas. The most outstanding peculiarities of its distribution in the Eastern Pacific are its absence from surface catches, as well as from the California Current, Mexican Current, Panamic Area, and Peruvian Current. Its optimum habitat probably is in deeper waters within the levels of photosynthesis, and in the most distinctively tropical regions.

8. Doryphorum Group. Of the five species of this group only *Phalacroma pugiunculus* was not found by the Expedition.

Phalacroma mucronatum, sp. nov.

Figure 22: 4, 6, 8

Diagnosis: — Body subcircular in lateral outline, sometimes slightly deeper anteriorly than posteriorly; length: depth, 1.07–1.11: 1. Posterior cingular list 0.33–0.41 the length of body from apex. Left sulcal list 0.50–0.54 the length of body; distance from R_1 to R_3 is 0.33–0.37 the length of body; R_2 is about 0.17, and R_3 about 0.30 the greatest depth of body; margin forms angle of 80°–90° at R_3; R_3 inclined posteriorly at 30°–40°. With triangular posterior sail, placed on antapex and directed posteriorly; when fully developed, its length is 0.28–0.40 the greatest depth of body, and it is somewhat narrower than long; without or with central rib; well separated from left sulcal list. Theca porulate (and finely areolate?). Length, 35.0–45.4 μ.

Eastern tropical Pacific.

Description: — A small species, the body of which is subcircular in lateral outline, deepest near the middle, and sometimes slightly deeper anteriorly than posteriorly. The ratio between the length and the depth is 1.07–1.11: 1. The longitudinal axis of the body is perpendicular to the girdle.

The epitheca is 0.89–0.94 as deep as the hypotheca, evenly and moderately convex, highest in the center, and moderately elevated or rather prominent above the anterior cingular list. The transverse furrow is flat or slightly convex, and its width is 0.5–1.0 the greatest height of the epitheca. The posterior cingular list is 0.33–0.41 the length of the body from the apex. The hypotheca is symmetrical, with well or moderately rounded dorsal and ventral margins; the posterior margin is rather strongly convex and confluent with the dorsal and ventral margins. The posterior portion of the hypotheca is of about the same width as, or slightly narrower than, the epitheca. The shape of the body in dorsoventral view is not known with certainty, as all the specimens drawn in this aspect were megacytic. It

appears to be rather narrowly obovate, widest somewhat in front of the middle, with rounded apices, and with the antapical end somewhat narrower than the epitheca.

The cingular lists are subhorizontal, subequal, and about as wide as the transverse furrow; their structure is unknown. The right sulcal list is unknown. The left sulcal list is of moderate length and width. Its length is 0.50–0.54 the length of the body, and the distance between the anterior and posterior main ribs is 0.33–0.37 the length of the body. The anterior main rib is 0.15–0.20, the fission rib about 0.17, and the posterior main rib about 0.30 the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is almost straight or slightly concave; at the posterior main rib it forms an angle of 80°–90°; behind the last-mentioned rib it is almost straight or slightly concave or convex. The main ribs of this list are of moderate strength, straight or almost so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is about 0.50 the distance between the anterior and posterior main ribs. The posterior rib has a posterior inclination of 30°–40°. Except for the three main ribs, this list appears to lack structural differentiations. On the right valve there is an acute, triangular posterior sail, which is located on the antapex and is directed posteriorly. When fully developed, its length is 0.28–0.40 the greatest depth of the body, and it is somewhat narrower at its base than it is long; sometimes its length is about twice the basal width. Its margins are almost straight or gently concave, convex or sigmoid, and the angle at its tip is 15°–40°. In some specimens this sail lacks structural differentiations, in others it has a central rib which may be divided at the base. The sail is well separated from the left sulcal list. The distance between these two structures is variable; in the specimens examined it equals at least half the basal width of the sail. There are no parasagittal lists.

The thecal wall has scattered pores. Areolation was not seen, but might have been overlooked.

Megacytic stages have been seen (Figure 22: 6).

The proportions of three specimens were measured.

Dimensions: — Length of body, 35.0–45.4 μ (average, 40.7 μ; type, 38.8 μ). Greatest depth of body, 32.6–41.2 μ (average, 36.2 μ; type, 34.9 μ).

Variations: — The five specimens examined are very similar. They exhibit variations mainly in the size of the body, the relative height of the epitheca, and the shape and structure of the posterior sail.

Comparisons: — The species is established on outline drawings of five Expedition specimens.

It probably has about the same habitus as the ancestral form from which *Phalacroma doryphorum*, *P. circumsutum*, *P. cuneolus*, and *P. pugiunculus* originated. The following of its characters are more or less primitive: its small size, its subcircular shape in lateral view, the relatively great height of its epitheca, the fact that its left sulcal list is relatively long and not unusually wide posteriorly, and that the posterior main rib of this list is not club-shaped. *Phalacroma mucronatum* differs from the four species mentioned in its smaller size and in the subcircular shape of its body. *Phalacroma doryphorum* appears to be its closest relative.

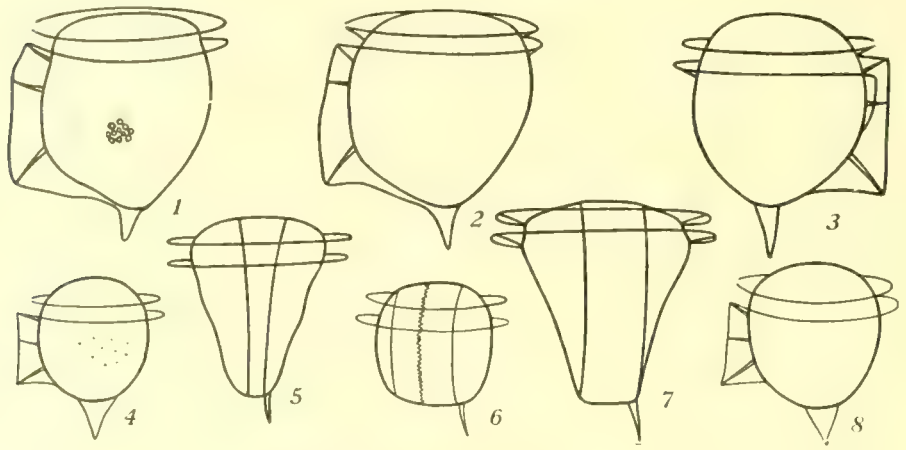

FIGURE 22.— 1, 2, 3, 5, 7, *Phalacroma cuneolus*, sp. nov. 1, 2, left lateral view; 3, right lateral view; 5, 7, dorsal view (megacytic). Surface markings, areolation, indicated only on small portion of theca in 1. 1, 5, from type specimen. × 430. Station 4711 (300–0 fathoms). 4, 6, 8, *Phalacroma mucronatum*, sp. nov. 4, 8, left lateral view; 6, dorsal view (megacytic). × 430. 4, 6, type specimen, from Station 4730 (300–0 fathoms); 8, from Station 4638 (300–0 fathoms).

Occurrence: — *Phalacroma mucronatum* is recorded at four of the 127 stations. There are 0, 1, 1, 1, 1, and 0 stations on the six lines of the Expedition. Of these four stations, one (4638) is in the Panamic Area, and three (4681, 4711, 4730) are in the South Equatorial Drift. All records refer to hauls from 300–0 fathoms only. Station 4730 is the type locality.

The temperature range of these four stations at the surface was 68°–79°; the average was 74.5°.

At one station (4638) the frequency is 2%; in the remaining cases it is less than 1%.

Phalacroma doryphorum Stein

Figure 23: 1–5; 24

Phalacroma doryphorum Stein, 1883, p. 23, pl. 19, fig. 1–4. Bütschli, 1885, p. 942. Schütt, 1895, p. 56, 89, pl. 4, fig. 19; 1899, p. 42, pl. 6, fig. 17. Murray & Whitting, 1899, p. 330, tab. 1–9. Lemmermann, 1899a, p. 319, 320, 372; 1901a, p. 372; 1905a, p. 35. Schröder, 1900a, p. 19; 1906a, p. 325, 327, 330; 1911, p. 25, 37. Cleve, 1900b, p. 1031; 1901a, p. 17; 1901c, p. 270; 1902b, p. 36; 1903b, p. 347. Schmidt, 1901, p. 137. Ostenfeld & Schmidt, 1901, p. 176. Entz, 1902b, p. 94; 1905, p. 111. Lohmann, 1902, p. 53; 1908a, p. 161; 1920, p. 484, 492, 568. Pavillard, 1905, p. 58, 81, 102; 1909, p. 283; 1915a, p. 2, fig. B; 1916, p. 47, 49, 50, 52, 60, fig. 12, pl. 3, fig. 8. Karsten, 1906, p. 185, 187, 189, 191; 1907, p. 228, 238, 240, 247, 257, 285, 295, 304, 318, 321, 334, 337, 340, 341, 343, 347, 348, 349, 352, 354, 355, 421, 438, 464, 471. Nathansohn, 1908, p. 604; 1909, p. 47; 1910a, p. 14, 17, 20; 1910b, p. 61. Gräf, 1909, p. 136. Stüwe, 1909, p. 252, 287. Hensen, 1911, p. 166, tab. 15. Okamura, 1912, p. 18, pl. 5, fig. 77. Schiller, 1912, p. 27. Forti, 1922, p. 104, 190, 208, fig. 107. Jörgensen, 1923, p. 16, 17, 37, 44, fig. 17. Forti & Issel, 1923, p. 3.

Diagnosis:—Body obovate or subovate in lateral outline, deepest at or generally somewhat behind girdle; length: depth, 1.05–1.17: 1. In dorsal view narrowly obovate or subcuneate; narrowly rounded or subacute posteriorly. Posterior cingular list 0.17–0.37 the length of body from apex. Cingular lists without ribs. Left sulcal list rather short, often high posteriorly; length, 0.41–0.55 the length of body; distance between R_1 and R_3 is 0.26–0.38 the length of body; R_2 is 0.11–0.17, R_3 is 0.24–0.45 the greatest depth of body; margin forms angle of 50°–90° at R_3; R_3 inclined posteriorly at 15°–40°, often club-shaped. With triangular posterior sail, either on or usually somewhat ventrally to antapex, and inclined ventrally at 0°–35°; when fully developed, its length is 0.20–0.37 the greatest depth of body, and it is about as wide as long or slightly narrower; with or without central rib or reticulation; usually well separated from left sulcal list. Theca finely and closely areolate. Length, 54–86 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, the body of which is obovate or subobovate in lateral outline, deepest at or in most specimens somewhat behind the girdle and 1.11 (1.05–1.17) times longer than deep. The longitudinal axis of the body is perpendicular to the girdle.

The epitheca is evenly and moderately convex to rather flat, highest in the center, and moderately or but slightly elevated above the anterior cingular list. In the Expedition specimens it is about 0.90 (0.85–0.92) as deep as the hypotheca; in the specimen represented by Stein (1883, pl. 19, fig. 2), on the other hand, the epitheca and the hypotheca are of about equal depth. The transverse furrow is flat or slightly convex, and its width is about 0.33–0.50 the greatest height of the epitheca. The posterior cingular list is 0.31 (0.17–0.37) the length of the body

from the apex. The hypotheca is symmetrical; sometimes it is, as Jörgensen (1923, p. 16) expresses it, of an "oval wedge-shape," with rather flat dorsal and ventral margins; sometimes it is regularly oval, with well or moderately rounded dorsal and ventral margins; the posterior margin is strongly convex and confluent with the dorsal and ventral margins. The posterior portion of the body is strikingly narrower than the anterior. In dorsoventral view (Stein, 1883, pl. 19, fig. 4; Okamura, 1912, pl. 5, fig. 77b) the body is narrowly obovate or subcuneate, widest somewhat in front of the middle, and narrowly rounded or subacute posteriorly.

The cingular lists are subequal and subhorizontal, or slightly inclined anteriorly; their width about equals the width of the transverse furrow, and they are hyaline, and without ribs or other structural differentiations. The right sulcal list ends at a point about halfway between the fission rib and the posterior main rib of the left sulcal list, or it extends to or even slightly beyond the posterior main rib of the last-mentioned list; in some specimens it is subtriangular, decreasing gradually in width posteriorly; in other specimens it is of almost equal width throughout its anterior half or even throughout the greater portion of its length; anteriorly it is about as wide as the transverse furrow. The left sulcal list is rather short, and often comparatively high posteriorly. Its length is 0.46 (0.41–0.55) the length of the body, and the distance between the anterior and posterior main ribs is 0.29 (0.26–0.38) the length of the body. The anterior main rib is 0.11 (0.08–0.14), the fission rib 0.13 (0.11–0.17), and the posterior main rib 0.31 (0.24–0.45) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list often is almost straight; sometimes it is gently concave or convex, or it is slightly sigmoid, concave anteriorly and convex posteriorly; at the posterior main rib it forms an angle of 70° (50°–90°); behind the last-mentioned rib it is almost straight, or gently concave or convex. The main ribs of this list are of moderate strength and straight or nearly so; in most of the specimens examined the posterior main rib is club-shaped (see also Schütt, 1895, pl. 4, fig. 19: 2, and Jörgensen, 1923, fig. 17); in the specimens drawn by Stein (1883), on the other hand, this rib is not club-shaped. The distance between the anterior main rib and the fission rib is 0.35–0.50 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 25° (15°–40°). Except for the three main ribs, this list seems to be without structure in most specimens; sometimes it may have a very faint reticulation. On the right valve there is an acute, triangular, posterior sail, which is situated either on or usually

somewhat ventrally to the antapex, and is inclined ventrally at 0°–35°. The size of this sail is somewhat variable, probably due to the fact that in each binary fission one of the daughter schizonts has to form this structure anew. When fully developed, its length is 0.20–0.37 the greatest depth of the body, and it is about as wide at the base as it is long or slightly narrower. Its margins are almost straight, or gently concave, convex, or sigmoid, and the angle at its tip is 40°–90°. In some specimens the sail has a central rib, in others it is more or less reticulated, especially in its central portion; sometimes both the central rib and the reticulation are developed, sometimes no structure can be distinguished. In most specimens the sail is well separated from the left sulcal list; the distance between these two structures is variable, but usually it equals at least half the basal width of the posterior sail. Only in one specimen (Figure 23: 5) were these structures connected, and this specimen appeared still to be in a condition of reorganization following binary fission. There are no parasagittal lists.

The thecal wall is finely and closely areolate and has scattered pores; the areoles are subequal or somewhat unequal in size. In the transverse furrow there are two rows of pores.

Megacytic stages have been recorded (see Pavillard, 1916, fig. 12, and Jörgensen, 1923, p. 17).

The proportions of seven Expedition specimens and of the specimens drawn by Stein (1883), Schütt (1895), Okamura (1912), and Jörgensen (1923) were measured.

Dimensions: — Length of body, 62.7–73.8 μ (average, 67.2 μ). Greatest depth of body, 56.7–62.8 μ. Though the size of the type specimen figured by Stein (1883, pl. 19, fig. 1) is not known it probably was somewhere between 69 μ and 104 μ long; and the specimen represented by Stein (1883, p. 31, pl. 19, fig. 2) was somewhere between 86 μ and 128 μ long. The specimen figured by Schütt (1895, pl. 4, fig. 19: 2) was about 70.5 μ long and 61.6 μ deep; Okamura's (1912, pl. 5, fig. 77) about 54 μ long and 48.7 μ deep; and Jörgensen's (1923) about 68 μ long and 62 μ deep. According to Lohmann (1902, p. 53), this species is 86 μ long.

Variations: — In spite of the fact that *Phalacroma doryphorum* is "a very characteristic and easily recognizable species" (Jörgensen, 1923, p. 16), it exhibits a considerable variability in several respects. The following characters are more or less strikingly variable: — the size and shape of the body, the relative height of the epitheca, the shape of the left sulcal list, the length and shape of the posterior main rib of this list, the position, direction, and struc-

ture of the posterior sail, and the distance between this structure and the left sulcal list.

Comparisons: — Under the name of *Phalacroma doryphorum*, Stein (1883, pl. 19, fig. 1, 2, 3) figures three specimens of fairly different habitus. One, the type specimen (pl. 19, fig. 1), has a regularly obovoidal body, deepest somewhat behind the girdle, and with comparatively high epitheca. The others (pl. 19, fig.

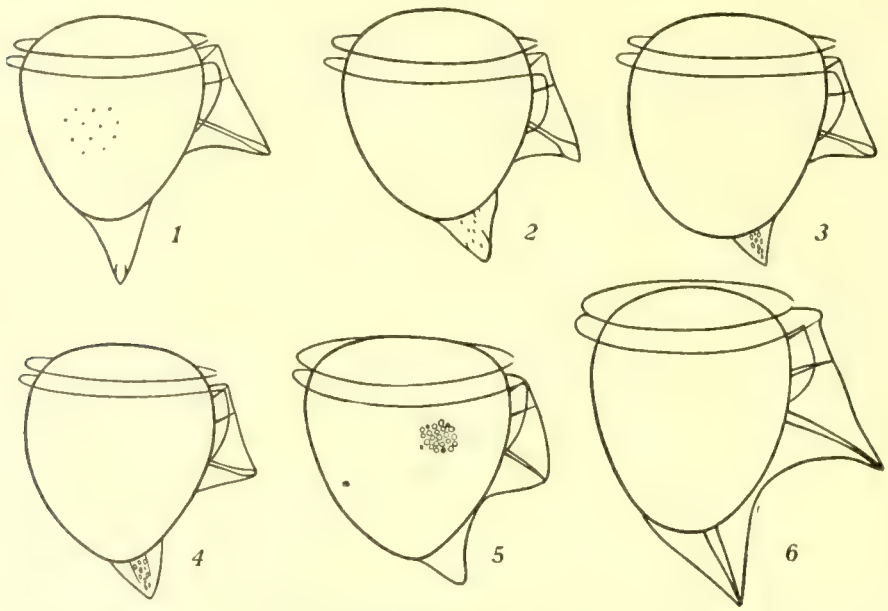

FIGURE 23.— 1–5, *Phalacroma doryphorum* Stein, right lateral view. Surface markings, areolation, and porulation indicated only on small portion of theca in 1 and 5. × 430. 1, from Station 4737 (300–0 fathoms); 2, from Station 4590 (300–0 fathoms); 3, 4, from Station 4664 (300–0 fathoms); 5, from Station 4681 (300–0 fathoms). 6, *Phalacroma circumsutum* Karsten, right lateral view. × 430. Station 4638 (300–0 fathoms).

2, 3) are deepest at the girdle, and have the epitheca rather flat and the hypotheca of an oval wedge-shape. The question as to whether or not these differences are specific cannot be settled. Most of the specimens in the material of the Expedition assigned to *P. doryphorum* agree fairly closely with the type specimen as far as the shape of the body is concerned, but differ in the shape and relative length of the left sulcal list and of its posterior main rib, and in the position and direction of the posterior sail. In spite of these differences our assignments may be regarded as fairly certain.

The specimens figured by Schütt (1895), Okamura (1912), and Jörgensen (1923) fall within the range of variations established for the Expedition specimens.

The structurally closest-known relative of *Phalacroma doryphorum* is *P. circumsutum*. The first species differs from the last mainly in having the left

sulcal list and the posterior sail well separated; furthermore, the posterior main rib of its left sulcal list generally is club-shaped.

Next to *Phalacroma circumsutum*, *P. mucronatum* appears to be the nearest-known relative of *P. doryphorum*. *Phalacroma mucronatum* probably agrees fairly closely with the ancestral form from which *P. doryphorum* evolved, as indicated by the following characteristics: — it is a small species, 35.0–45.4 μ long, subcircular in lateral view, with rather high epitheca, with the left sulcal list relatively long and not exceptionally wide posteriorly, and with the posterior main rib of this list not club-shaped.

Phalacroma cuneolus and *P. pugiunculus* may possibly also belong to the same evolutionary series as *P. doryphorum;* the last is readily distinguished from these two species by its regularly obovoidal body and wider posterior sail.

With regard to the possible relationship between *Phalacroma doryphorum* and *P. ovum*, see the section on comparisons (p. 120).

Synonymy: — With regard to Jörgensen's (1923, pl. 17) assumption that figure G: 2, of *Dinophysis galea* Pouchet (1883), represents a specimen of *Phalacroma doryphorum*, see *P. circumsutum*, p. 184.

Occurrence: — *Phalacroma doryphorum* is recorded at seventy-five of the 127 stations. There are 16, 21, 8, 9, 12, and 9 stations on the six lines of the Expedition. Of these seventy-five stations, one (4583) is in the California Current; twelve (4587, 4588, 4590, 4592, 4594, 4596, 4598, 4600, 4604, 4605, 4545, 4546) are in the Mexican Current; nine (4609, 4611, 4613, 4617, 4619, 4631, 4634, 4637, 4644) are in the Panamic Area; twenty (4646, 4647, 4648, 4650, 4651, 4652, 4655, 4659, 4660, 4661, 4662, 4663, 4664, 4665, 4667, 4669, 4671, 4675, 4676, 4678) are in the Peruvian Current; five (4689, 4691, 4695, 4697, 4699) are in the Easter Island Eddy; two (4713, 4715) are in the Galapagos Eddy; twenty (4679, 4681, 4683, 4701, 4707, 4709, 4711, 4717, 4719, 4720, 4721, 4722, 4724, 4728, 4730, 4732, 4734, 4737, 4739, 4740) are in the South Equatorial Drift; three (4742, 4743, 4540) are in the South Equatorial Current; two (4541, 4542) are in the Equatorial Counter Current; and one (4543) is in the North Equatorial Current. There are twenty-six records from the surface (Stations 4583, 4588, 4592, 4596, 4600, 4604, 4611, 4617, 4619 [Salpa], 4631, 4644, 4648, 4660 [Salpa], 4664 [Salpa], 4669, 4675, 4676, 4678, 4720 [Salpa], 4743, 4540, 4541, 4542, 4543, 4545, 4546); at four of these stations (4648, 4664, 4675, 4676) the species was taken in hauls from 300–0 fathoms as well as at the surface; at the other twenty-two stations in surface hauls only. At one station (4652) the species is recorded from 100–0 fathoms; at one station (4737) from 100–0 fathoms and 300–0 fathoms; at one station

(4655) from 400–0 fathoms; at two stations (4701, 4724) from 300–0 fathoms and 800–0 fathoms; at three stations (4647, 4751, 4662) from 800–0 fathoms only. All the remaining records refer to hauls from 300–0 fathoms only.

The species is also recorded from surface waters in Acapulco Harbor, off the Mexican Current. This station is not included in the 127 stations mentioned above.

The temperature range of these seventy-five stations at the surface was 65°–85°; the average was 75.3°. At the twenty-six stations in the surface catches of

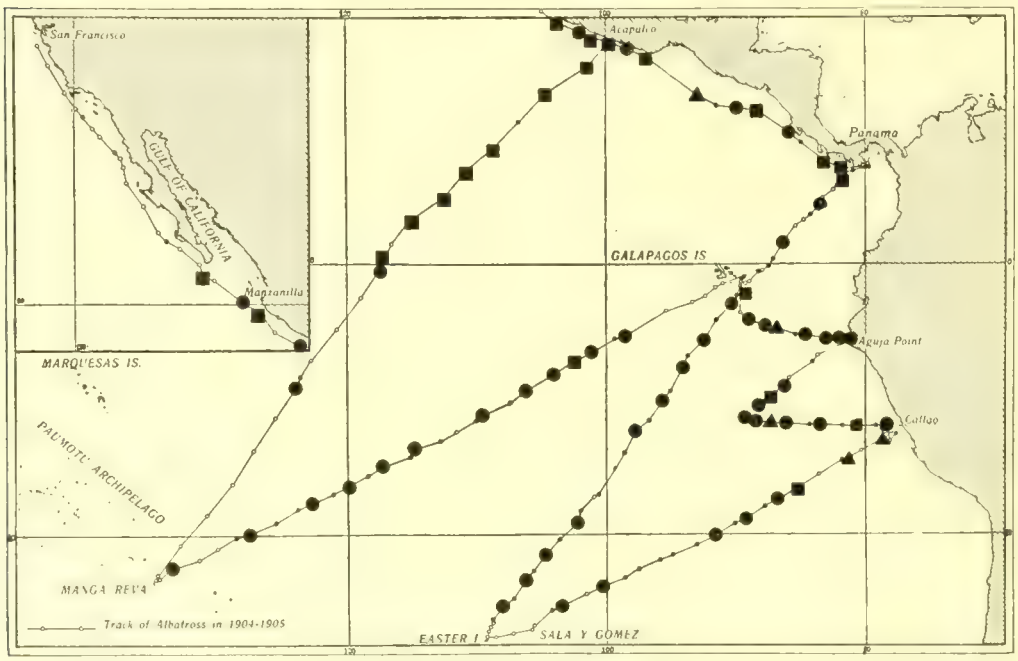

FIGURE 24.— Occurrence of *Phalacroma doryphorum* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

which this species was found, the surface temperature ranged from 67° to 84°; the average was 76.9°. At Acapulco it was 83°.

For the surface catches the following frequencies are recorded: — 7% at one station (4546), 5% at one station (4619), 3% at one station (4604), 2% at two stations (4669, 4675), 1% at eight stations (4600, 4617, 4720, 4743, 4540, 4541, 4543, 4545), and less than 1% at the remaining stations. For the catches from 100, 300, 400, or 800 fathoms to the surface the records of frequency are as follows: — 5% at one station (4663), 4% at one station (4590), 3% at five stations (4598, 4664, 4667, 4713, 4715), 2% at three stations (4675, 4689, 4699), 1% at

nineteen stations (4605, 4613, 4634, 4637, 4647, 4648, 4651, 4671, 4676, 4679, 4691, 4695, 4697, 4701, 4719, 4722, 4730, 4737, 4739), and less than 1% at the remaining stations. For the catch made in Acapulco Harbor the frequency of 1% is recorded.

The species was first recorded by Stein (1883) "aus dem Atlantischen Meer und der Südsee." Murray and Whitting (1899), who recorded it from the Atlantic, between lat. 43°4′ N. and lat. 0°16′ S., and from the Caribbean Sea, found it to occur "pretty constantly over the whole region examined." According to Cleve (1901c, 1902b, 1903b) it occurs in the Atlantic, between lat. 57° N. and lat. 39° S., and in the Caribbean Sea; only one of Cleve's several stations is located north of lat. 48° N., and this station, lat. 57° N., long. 14° W., is in the Gulf Stream. Hensen (1911) found it at a fairly great number of stations in various parts of the tropical and subtropical regions of the Atlantic. Lemmermann (1899a), Karsten (1906), and Stüwe (1909) recorded it from the Guinea Current; Lohmann (1920) from the Brazil Current, lat. 15° S., long. 34° W.; Jörgensen (1923) from the Bay of Cadiz and off the southwest coast of Portugal. From the Mediterranean there are the following records. Jörgensen (1923) found it at a very great number of stations "throughout the whole of the Mediterranean." Cleve (1903b) recorded it at lat. 37° N., long. 2° W.–8° E.; Pavillard (1905, 1909, 1915a, 1916) in the Gulf of Lyons; Nathansohn (1908, 1909, 1910a) off Monaco; Forti (1922) in the Ligurian Sea; Schröder (1900a) at Naples; Entz (1902b, 1905), Schröder (1911), and Schiller (1912), in the Adriatic Sea. Cleve (1900b, 1903b) and Ostenfeld and Schmidt (1901) found it in the Red Sea; Ostenfeld and Schmidt (1901) and Schröder (1906a) in the Gulf of Aden; Cleve (1901a, 1903b) and Schröder (1906a) in the Arabian Sea; Cleve (1901a) and Karsten (1907) in the Indian Ocean; Schröder (1906a) near Singapore; Schmidt (1901) in the Gulf of Siam; Okamura (1912) in Japanese waters; and Lemmermann (1899a) in the Pacific Ocean at lat. 6° N., long. 111° W. and lat. 12° N., long. 117° W.

Most of the records referred to in the last paragraph were from surface hauls. The only records of closing-net hauls published as yet are the following by Karsten (1907):— Station 227, lat. 2°56′ S., long. 67°59′ E., 1000–800 m.; Station 228, lat. 2°38′ S., long. 65°59′ E., 420–350 m.; Station 229, lat. 2°38′ S., long. 63°37′ E., 1600–1400 m.; Station 239, lat. 5°42′ S., long. 43°36′ E., 120–105 m.; Station 268, lat. 9°6′ N., long. 53°41′ E., 105–88 m. and 63–46 m.

All the specimens recorded were reported as "living."

According to these authors, this species occurs in waters of the following temperatures and salinities.

	Temperature	Range	Number and Mean of Observations		Salinity	Range	Number and Mean of Observations	
Murray and Whitting (1899)	60°–85°							
Cleve (1901a)		79.1°–86.7°				34.77–34.69		
Cleve (1901c)		57.9°–82.8°	55	71.6°		33.88–38.48	41	35.96
Cleve (1902b)	68.1°						11	36.12
Cleve (1903b)		60.3°–84.5°	14	75.9°		35.97–40.70	14	37.08
Ostenfeld & Schmidt (1901)	72.1°–80.1°							
Stüwe (1909)	68.5°–75.2°							

Of the authors who have contributed toward our knowledge of the distribution of this species only Stein (1883), Pavillard (1916), Okamura (1912), Forti (1922), and Jörgensen (1923) give descriptions or drawings by means of which their determinations of this species may be judged.

This species appears to be one of the most common representatives of Dinophysoidae (Jörgensen, 1923, p. 17). It is eupelagic and widely distributed in tropical, subtropical, and warm-temperate seas. Occasionally it is carried by warm currents into cooler regions (Cleve, 1901c). According to the Expedition records it is the most common species of this tribe and is almost evenly distributed throughout the area investigated. Although it probably has its optimum habitat in deeper waters, within the levels of photosynthesis, it is rather frequent at the surface. *Phalacroma doryphorum*, *P. rapa*, *P. cuneus*, and *P. favus* occur more frequently in the surface catches than any other species of Phalacroma; the numbers of surface records are 26, 22, 13, and 6, respectively; there are more surface records of *P. doryphorum* than of any other species of Phalacroma.

Phalacroma circumsutum Karsten

Figure 23: 6

Phalacroma circumsutum Karsten, 1907, p. 421, pl. 53, fig. 8. Steuer, 1910, p. 476, 478, fig. 246a; 1911, p. 252, fig. 214a. Jörgensen, 1923, *partim*, p. 17, 43.
?Dinophysis galea Pouchet, 1883, *partim*, p. 426, fig. G: 2.

Diagnosis: — Body obovate in lateral outline, deepest somewhat in front of middle; length: depth, 1.20–1.23: 1. Posterior cingular list 0.24–0.26 the length of body from apex. Cingular lists without ribs, sometimes inclined anteriorly at 10°–30°. Left sulcal list: distance between R_1 and R_3 is 0.33–0.38 the length of body; R_2 is 0.20–0.22, R_3 is 0.42–0.55 the greatest depth of body; margin acuminate at R_3 at angle of 35°–70°; R_3 inclined posteriorly at 25°. With acute, almost equilaterally triangular posterior sail supported by strong central rib, which is 0.43 the greatest depth of body, placed somewhat ventrally to antapex and in-

clined ventrally at 15°–20°; angle at tip of sail, 50°. Left sulcal list and posterior sail connected by list with minimum width 0.3–0.5 the width of transverse furrow, with or without parasagittal list along dorsal side of hypotheca. Theca finely and closely areolate. Length, 75.7–80.0 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — A medium-sized species, with the body obovate in lateral outline, deepest somewhat in front of the middle and 1.20–1.23 times longer than deep. The longitudinal axis of the body is perpendicular to the girdle.

The epitheca is 0.87–0.90 as deep as the hypotheca, highest in the center, of moderate convexity or rather flat, and moderately or but slightly elevated above the anterior cingular list. The transverse furrow is flat or but slightly convex; and its width is 0.50–0.60 the greatest height of the epitheca. The posterior cingular list is 0.24–0.26 the length of the body from the apex. The hypotheca is symmetrical; its ventral, posterior, and dorsal margins are confluent; the ventral and dorsal margins are of moderate convexity; the posterior margin is strongly convex. The posterior part of the body is strikingly narrower than the anterior.

The cingular lists are subequal, and either subhorizontal or inclined anteriorly at about 10°–30°; their width about equals or somewhat exceeds the width of the transverse furrow; and they appear to lack ribs and other structural differentiation. The right sulcal list extends almost to the posterior main rib of the left sulcal list; its anterior half is about as wide as the cingular lists, *i.e.*, it is decidedly narrower than the left sulcal list; posteriorly the list decreases gradually in width. The left sulcal list is of moderate length and rather wide posteriorly. The distance between the anterior and the posterior main ribs is 0.33–0.38 the length of the body. The anterior main rib is 0.18–0.19, the fission rib 0.20–0.22, and the posterior main rib 0.42–0.55 the greatest depth of the body; behind the posterior main rib the list decreases suddenly in width. The free margin of this list is gently concave or almost straight between the anterior main rib and the fission rib, as well as between the fission rib and the posterior main rib; at the posterior main rib it is more or less acuminate and forms an angle of 35°–70°; behind the posterior main rib it is gently concave. The main ribs of this list are of moderate strength and none of them is club-shaped or otherwise modified; the anterior main rib and the fission rib are straight or almost so, the posterior main rib is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.30–0.45 the distance from the anterior to the posterior main rib. The posterior main rib has a posterior inclination of about 25°. Disregarding the three main ribs, this list appears to lack structural differentiation. On the right valve

there is an acute, almost equilaterally triangular posterior sail supported by a strong rib which arises somewhat ventrally to the antapex and ends at the tip of the sail. This rib has a ventral inclination of 15°–20°, and its length is about 0.43 the greatest depth of the body; *i.e.*, it is about as long as or somewhat shorter than the main rib of the left sulcal list. The margins of this sail are almost straight or slightly curved, and the angle at its tip is about 50°. The posterior sail and the left sulcal list are connected by a short, but well-developed list, which at its narrowest place is about 0.3–0.5 as wide as the transverse furrow. The connecting list and the posterior sail, disregarding the main rib of the latter, appear to lack structural differentiation. The type specimen (Karsten, 1907, pl. 53, fig. 8) had an apparently structureless parasagittal list extending, on the dorsal side of the hypotheca, from the posterior cingular list to the posterior sail but not forming a direct continuation of the latter; this list was widest posteriorly and decreased gradually in width anteriorly; its greatest width about equaled that of the transverse furrow.

The structure of the theca is about the same as in *Phalacroma doryphorum; i.e.*, the wall is finely and closely areolate and furnished with scattered pores.

Megacytic stages have not been seen.

Dimensions: — Length of body, 75.7 μ. Greatest depth of body, 61.5 μ. Type specimen (Karsten, 1907, pl. 53, fig. 8): Length of body, 80.0 μ. Greatest depth of body, 66.7 μ.

Variations: — Very little is known about the variability of this species. The Expedition specimen differs from the type mainly in being slightly smaller (75.7 μ as compared with 80.0 μ), in having a slightly higher epitheca and a somewhat longer posterior main rib in the left sulcal list, and in lacking a parasagittal list along the dorsal side of the hypotheca. The specimen represented by Pouchet's (1883) figure G:2, of *Dinophysis galea* has been disregarded because of the impossibility of being certain that his figure represents *P. circumsutum.*

Comparisons: — In spite of the several differences mentioned in the last section between the type of *Phalacroma circumsutum* and the Expedition specimen, the determination of the last seems justifiable. The differences in the size of the body, in the height of the epitheca and in the length of the posterior main rib of the left sulcal list appear of little systematic importance, since they are within the range of variation established for the closely-related species, *P. doryphorum.* The "parasagittal list" along the dorsal side of the hypotheca in the type of *P. circumsutum* may be the intercalary zone not yet resorbed following binary fission. It should be noted that this list does not form a direct continua-

tion of the posterior sail as it does in *P. limbatum*, *P. pulchrum*, and in other species of this genus. Furthermore, in the closely related *P. doryphorum*, Pavillard (1916, p. 53) frequently found specimens "en voie de reconstitution portant encore des fragments irréguliers de la zone intercalaire le long de la ligne de suture."

Phalacroma circumsutum is structurally very similar to *P. doryphorum* (see Karsten, 1907, p. 426; and Jörgensen, 1923, p. 17), differing mainly in having the left sulcal list and the posterior sail connected by a rather wide sail; in addition, the posterior main rib of its left sulcal list is not club-shaped. See also *P. doryphorum*, p. 178.

Synonymy: — *Phalacroma circumsutum* Jörgensen (1923) evidently includes two systematic units. Jörgensen (1923, p. 17) writes as follows: "Besides a larger form, answering to Karsten's figure, with protracted lower end of left longitudinal fin (at the supporting spine) and large, somewhat ventrally directed terminal spine, there occurred in the 'Thor' material also a smaller and divergent form, with downward trending terminal spine, and slightly prominent corner of left longitudinal fin, shape of cell in profile broader in proportion, and epitheca higher." Of these two "forms" the larger probably should be assigned to *P. circumsutum* Karsten; the smaller, which is figured (Jörgensen, 1923, fig. 18), belongs to *P. pulchrum* Kofoid and Michener.

Of the four specimens represented by Pouchet (1883) under the name of *Dinophysis galea*, one (Pouchet, 1883, fig. G: 2) resembles *P. circumsutum* in the shape of its body and in having its large, triangular posterior sail connected with the left sulcal list by a rather wide sail. It differs from this species in having the left sulcal list relatively narrow posteriorly, in having two instead of one posterior main rib in this list, in lacking a central rib in its posterior sail, and in having its posterior sail directed posteriorly instead of posteroventrally. Jörgensen (1923, p. 37) assigns this specimen to *P. doryphorum*. This identification is contradicted by the fact mentioned above that, according to Pouchet's (1883) drawing, this specimen had the posterior sail connected with the left sulcal list by a fairly wide sail and by the shape of the left sulcal list. It may be noted in this connection that Pavillard (1916) found *P. doryphorum* to be common in the Gulf of Lyons, which is the type locality of *Dinophysis galea;* on the other hand, he never recorded *Phalacroma circumsutum* from these waters in spite of very intensive investigations. This fact, of course, seems to support Jörgensen's (1923) identification above mentioned. Pouchet's figure must be considered as insufficient for certainty of specific assignment until the question as to the occasional occurrence in *P. doryphorum* of a connection between the left sulcal list and the posterior sail is settled and until the variability of the left sulcal list and of the posterior sail in *P. circumsutum* has been further investigated.

The four specimens figured by Pouchet (1883) under the name of *Dinophysis galea* belong to four different species, two of which (fig. G: 1, 4) are referable to Ornithocercus, one (fig. G: 2) to Phalacroma, and one (fig. G: 3) to Ceratocorys. Since of these four figures, figure G: 2 appears to be the most accurate, it is suggested that it represent *D. galea*. This name antedates both *doryphorum* and *circumsutum*.

Occurrence: — This species is recorded at only one of the 127 stations. This station (4638) is on the second line of the Expedition and in the Panamic Area. The depth is 300–0 fathoms, the surface temperature 75°, and the frequency 1% (one specimen).

Karsten (1907), who found this species in the Indian Ocean, did not give any information as to the type locality. Jörgensen (1923) recorded it from a few stations in the Mediterranean (the THOR Expedition) and from the Guinea Current (the German South Pole Expedition). With regard to Jörgensen's (1923) data, see above.

This species, which is eupelagic, appears to be very rare and limited to tropical, subtropical, and warm-temperate waters.

Phalacroma cuneolus, sp. nov.

Figure 22: 1, 2, 3, 5, 7

Diagnosis: — Body subobovate in lateral outline; epitheca moderately convex to rather flat; ventral margin of hypotheca may form broadly rounded corner at R_3 of left sulcal list; deepest somewhat behind girdle; length: depth, 1.10–1.28: 1. In dorsal view cuneate; hypotheca acute to subacute posteriorly, its side contours gently concave or gently undulating; length: width, 1.44: 1. Posterior cingular list 0.22–0.33 the length of body from apex. Cingular lists may be somewhat inclined anteriorly. Left sulcal list of moderate length and width; distance between R_1 and R_2 0.45–0.52 the length of body; R_2 is 0.13–0.20, and R_3 is 0.26–0.31 the greatest depth of body; margin forms angle of 70°–100° at R_3; R_3 inclined posteriorly at 40°–55°. With rather narrow, triangular posterior sail, located on antapex and directed posteriorly; 0.18–0.31 the greatest depth of body in length, and 0.40–0.80 as wide as long; often connected with left sulcal list by narrow list. Theca finely and closely areolate. Length, 59.0–74.0 μ.

Eastern tropical Pacific.

Description: — A medium-sized species, the body of which is subobovate in lateral outline, with moderately convex to almost flat epitheca, with the posterior portion of the hypotheca more or less narrowly rounded, with the ventral margin of the hypotheca sometimes broadly rounded-angular at the posterior main rib of the left sulcal list, and with the greatest depth somewhat behind the girdle. The ratio between the length and the depth of the body is 1.16 (1.10–1.28): 1. The longitudinal axis is perpendicular to the girdle, or it has a slight postero-ventral inclination.

The epitheca is 0.88 (0.86–0.90) as deep as the hypotheca, evenly and moderately convex to rather flat, highest in the center, and moderately to rather slightly elevated above the anterior cingular list. The transverse furrow is flat, or slightly concave or convex, and its width is 0.60–1.10 the greatest height of the epitheca. The posterior cingular list is 0.26 (0.22–0.33) the length of the body from the apex. Some specimens (Figure 22: 3) have the hypotheca subsymmetrical. In these specimens the dorsal and ventral margins of the hypotheca are of moderate to gentle convexity, sometimes with almost even curvature, sometimes more or less flattened posteriorly; the postmargin is confluent with the dorsal and ventral margins, subrectangular, gently convex or almost straight dorsally and ventrally,

and strongly rounded at the antapex. Other specimens, the type (Figure 22: 1), which are somewhat asymmetrical, have the dorsal margin of the hypotheca of about the same shapes as the subsymmetrical specimens, but the ventral margin is more or less irregular, being broadly rounded-angular at the posterior main rib of the left sulcal list; the postmargin is subrectangular, rather narrowly rounded at the antapex, and its ventral portion is gently convex to straight, or even slightly concave. Between these two types of hypotheca, transitional forms are to be found (Figure 22: 2). In dorsoventral view the body is cuneate, widest at the girdle, and about 1.44 times longer than wide. The epitheca is broadly rounded to rather flat; the hypotheca is acute to subacute posteriorly, and its side contours are gently undulating, as in the type specimen (Figure 22: 5), or gently concave or convex.

The cingular lists are subhorizontal or somewhat (10°–25°) inclined anteriorly, subequal, and about as wide as or slightly wider than the transverse furrow; their structure is unknown. The right sulcal list (observed in only one of the specimens; Figure 22: 3) extends to a point about halfway between the fission rib and the posterior main rib of the left sulcal list; it is subtriangular in shape, decreasing gradually in width posteriorly, and anteriorly about half as wide as the transverse furrow. The left sulcal list is of moderate length and width. The distance between the anterior and posterior main ribs is 0.47 (0.45–0.52) the length of the body. The anterior main rib is 0.16 (0.13–0.18), the fission rib 0.16 (0.13–0.20), and the posterior main rib 0.29 (0.26–0.31) the greatest depth of the body. Between the anterior and posterior main ribs the free margin of this list is straight, gently convex or concave, or slightly irregular (Figure 22: 1); at the posterior main rib it forms an angle of about 90° (70°–100°). When this list is not connected with the posterior sail, its margin behind the posterior main rib is straight, or slightly concave or convex. The main ribs of this list are of moderate strength, straight or almost so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.33 (0.29–0.40) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 40°–55°. It is not known whether this list has any structure besides the three main ribs. On the right valve there is an acute, rather narrow, triangular posterior sail, which is located on the antapex and directed posteriorly. When fully developed its length is 0.18–0.31 the greatest depth of the body, and it is, at the base, 0.40–0.80 as wide as long. Its margins are almost straight, or gently convex, concave, or sigmoid, and the angle at its tip is 20°–40°. Its structure is unknown. In some specimens (Figure 22: 3) the posterior sail is

separated from the left sulcal list by a distance that about equals or even exceeds its basal width. In other specimens (Figure 22: 1, 2) these two structures are connected by a rather narrow list.

The thecal wall is finely and closely areolate. Porulation was not observed.

Megacytic stages were seen.

The dimensions of five specimens were measured.

Dimensions: — Length of body, 59.0–74.0 μ (average, 64.2 μ; type, 60.3 μ). Greatest depth of body, 51.3–58.0 μ (average, 54.3 μ; type, 51.3 μ).

Variations: — This species is rather strikingly variable in the following characters: the shape and relative height of the epitheca, the shape of the ventral margin of the hypotheca, the shape of the side contours of the hypotheca in dorsoventral view, the development of the list connecting the left sulcal list with the posterior sail, and the inclination of the cingular list.

The structurally closest-known relative of *Phalacroma cuneolus* is *P. pugiunculus*. These two species agree rather closely in the shape of the body in lateral view, in the shape and relative size of the left sulcal list, and in the shape, direction, and relative size of the posterior sail. The outline of *P. pugiunculus* in dorsoventral view is unknown. The latter species can be distinguished from the former by its smaller size (49–53 μ as compared with 59–74 μ). The position of these two species is not readily established because of their simplicity. We have placed them preliminarily with *P. mucronatum*, *P. doryphorum*, and *P. circumsutum* on account of the general resemblance in the shape of the body in lateral view and because of the presence of a posterior sail.

The outline of the body of *Phalacroma cuneolus* in dorsoventral view is suggestive of *P. cuneus* and *Dinophysis expulsa* and their near relatives. However, this similarity probably is due to convergence and can hardly be considered as an indication of close relationships.

Occurrence: — *Phalacroma cuneolus* is recorded at only one (4711, type locality) of the 127 stations, on the fourth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, and at a surface temperature of 75°. The frequency is less than 1% (six specimens).

9. Praetextum Group. The single member of this group, viz., *Phalacroma praetextum*, differs so strikingly from the remaining species of Phalacroma in having a ventral cribriform plate on the hypotheca that it is made the type of a new subgenus, Ethmophalacroma, subgen. nov.

Phalacroma praetextum Kofoid and Michener

Plate 4, fig. 6, 7. Figure 25: 4, 5

Phalacroma praetexta Kofoid & Michener, 1911, p. 291.

Diagnosis: — Body rounded subbiconical in lateral outline, slightly broader posteriorly than anteriorly; deepest at girdle, 1.12 times longer than deep. In dorsal view subbiconical, with broadly rounded apices, and 1.17 times longer than wide. Posterior cingular list 0.51–0.53 the length of body from apex. Cingular lists about half as wide as transverse furrow, reticulated. Left sulcal list 0.34 the length of body, subtriangular, gradually decreasing in width posteriorly; anteriorly about as wide as transverse furrow; R_1 and R_2 weak, straight, and simple, R_3 absent. On ventral side of hypotheca a dumbbell-shaped, cribriform plate extending from girdle to antapex. Theca with heavy and rather wide-meshed reticulation; about fifteen polygons border the girdle posteriorly. Length, 61–62 μ.

Eastern tropical Pacific.

Description: — A rather small species, the body of which is rounded subbiconical in lateral outline, slightly broader posteriorly than anteriorly, and deepest at the girdle. The ratio between the length and the depth of the body is 1.12: 1. The longitudinal axis is about perpendicular to the girdle.

The epitheca is about as deep as or slightly deeper than the hypotheca, highest in the center, subconical, gently convex dorsally and ventrally, evenly and fairly broadly convex anteriorly, with the dorsal, anterior, and ventral margins confluent, and very prominent above the anterior cingular list. The transverse furrow is somewhat concave and its width is about 0.22–0.27 the greatest height of the epitheca. The posterior cingular list is 0.51–0.53 the length of the body from the apex. The hypotheca has almost the same shape as the epitheca but is somewhat more rounded; its posterior portion, therefore, is somewhat broader than the anterior portion of the epitheca; see the description of the structure of the theca. In dorsoventral view the body is subbiconical, with fairly broadly rounded apices, and with the side contours of the epitheca and of the hypotheca almost straight or slightly concave; it is widest at the girdle, and about 1.17 times longer than wide; see below, the description of the structure of the theca.

The cingular lists are subhorizontal, subequal, and about half as wide as the transverse furrow. Along the base of the anterior of these lists there is a series of ribs anastomosing into a row of polygons in the same way as for *Phalacroma cuneus*

Schütt (1895, pl. 3, fig. 14:2); the number of these polygons and the structure of the posterior cingular list are unknown. The sulcus is about half as long as the hypotheca. The flagellar pore is at the junction of the cingulum and the sulcus. On the ventral side of the left valve a fairly small pore is found near the sagittal suture, just behind the anterior cingular list. The right sulcal list is about half as long as the left sulcal list; posteriorly it gradually decreases in width, or its ventral margin is gently sigmoid, convex anteriorly and concave posteriorly; its greatest width somewhat exceeds half the width of the transverse furrow. The left sulcal list is 0.34 the length of the body, subtriangular, gradually decreasing in width posteriorly; anteriorly it is about as wide as the transverse furrow; it has two fairly weak, straight, and simple ribs, both of which are located in the anterior half of the list; the posterior main rib is absent (Plate 4, fig. 7). There are no accessory lists or sails.

On the ventral side of the hypotheca, just to the left of the sulcus, there is a dumbbell-shaped area, extending on both sides of the sagittal suture from the posterior cingular list to the antapex. Due to the fact that it is bordered by the posterior cingular list and by the sulcus, its anterior half is truncate and somewhat asymmetrical. The constriction in the middle is rather slight. This area, which has a maximum width of about 0.33 the dorsoventral diameter of the transverse furrow, is characterized by a structure quite different from that of the remaining portion of the theca. It has a faint reticulum of very small polygons, and in the center of each or at any rate of most of these polygons there is an exceedingly fine pore. In other words, this area has the structure of a cribriform plate. It is not known whether this area is permanent, or whether it is temporary and formed just before fission. The first alternative, which appears the more plausible, is suggested by the relative position of this area to the girdle, by the absence of an intercalary zone from the dorsal side of the body and from the ventral side of the epitheca, by the peculiar shape and structure of this area, and by the fact that an area of this kind was found in both the specimens. If this area is of an intercalary nature, then the non-megacytic specimens probably have the ventral margin of the hypotheca resembling that of *Phalacroma reticulatum*, and the posterior portion of their hypotheca is somewhat narrower than in the specimens described above.

The thecal wall has a heavy reticulum of rather large polygons, except in the cribriform plate described in the last paragraph. Most of the polygons are subuniform in size, and on each valve about fifteen of them border the posterior margin of the girdle. Each valve of the epitheca has about fifty-eight and each

valve of the hypotheca about seventy-six polygons. In the transverse furrow there are two rows of polygons, each row with fourteen to sixteen polygons on each valve; near the junction of the cingulum and the sulcus these two rows may merge into a single row. Except in the cribriform plate, pores have not been seen.

With regard to megacytic stages, see p. 190.

The dimensions of one specimen, the type, were measured.

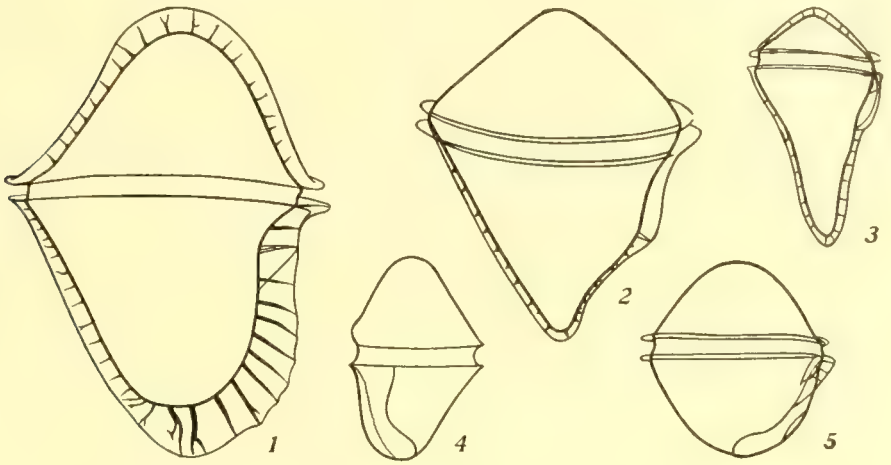

FIGURE 25.— 1, *Phalacroma fimbriatum* Kofoid and Michener, right lateral view of type specimen. × 430. Station 4613 (300–0 fathoms). 2, *Phalacroma reticulatum* Kofoid, right lateral view of type specimen. × 430. Station 4740 (300–0 fathoms). 3, *Phalacroma turbineum* Kofoid and Michener, right lateral view of type specimen. × 430. Station 4681 (300–0 fathoms). 4, 5, *Phalacroma praetextum* Kofoid and Michener; 4, oblique ventral view of detached left valve; 5, right lateral view of type specimen. × 430. Station 4742 (300–0 fathoms).

Dimensions: — Length of body, 61–62 μ (type, 61 μ). Greatest depth of body, 53.3 μ (type).

Comparisons:—The small size, the subcircular shape of the body in lateral view, the subequatorial position of the girdle, the relatively slight development of the cingular and sulcal lists, and the absence of accessory lists and sails are fundamental primitive features, which place this species among the most primitive living representatives of Phalacroma. On the other hand, the surface structure of the theca is better developed than in most species of the genus, and the cribriform plate of the hypotheca is unique and places the species in a rather isolated position. The species therefore appears to be a representative of a short evolutionary branch which split off at an early stage in the phylogenetic differentiation of the genus.

Phalacroma praetextum approaches *P. fimbriatum*, *P. reticulatum*, and *P. turbineum* in the tendency of its epitheca and hypotheca to taper toward the

apices, and in the heavy and coarse reticulation of its thecal wall. However, in most respects it differs more or less strikingly from these three species, and it must be regarded as an open question whether or not the three characters mentioned above are indicative of a close relationship. *Phalacroma praetextum* resembles *P. apicatum* in the subbiconical shape of the body in dorsoventral view, in the reticulated structure of the anterior cingular list, and in the absence of posterior angularity in the free margin of the left sulcal list. *Phalacroma praetextum* is easily distinguished from all the known species by the large cribriform plate of its hypotheca.

Occurrence: — *Phalacroma praetextum* has thus far been recorded at only one (4742, the type locality) of the 127 stations, on the sixth line of the Expedition, in the South Equatorial Current, from 300–0 fathoms, and at a surface temperature of 77°. The frequency is less than 1% (two specimens).

10. Reticulatum Group. On account of the striking difference between the left sulcal list of the three members of this group, viz., *Phalacroma fimbriatum*, *P. reticulatum*, and *P. turbineum*, and that of the typical members of Phalacroma, it appears advisable to give this group the rank of a subgenus: Retephalacroma, subgen. nov., with *P. turbineum* the type.

Phalacroma fimbriatum Kofoid and Michener

Plate 2, fig. 1. Plate 4, fig. 4. Figure 25: 1

Phalacroma fimbriata Kofoid & Michener, 1911, p. 289.

Diagnosis: — Body subbiconical in lateral view, with well-rounded apices, deepest at girdle, 1.35–1.40 times longer than deep. In dorsal view biconical, subacute anteriorly, narrowly rounded posteriorly; but slightly narrower than in lateral view. Posterior cingular list 0.43 the length of body from apex. Each cingular list with twelve branched ribs on each valve. Margin of right sulcal list widely angular in the middle. Two parasagittal lists encircle body; the right one, which is much wider than the left, merges so completely into left sulcal list that the boundary between these two lists cannot be established. Right parasagittal list widest and of nearly uniform width on ventral and posterior sides of hypotheca, where it is 0.14–0.20 the greatest depth of body; on dorsal side of hypotheca and on epitheca it is about half this width. Parasagittal lists with numerous ribs, some of which are irregular and branched. Theca with heavy reticulation, forming large polygons; about ten polygons border girdle posteriorly. Length, 118 μ.

Eastern tropical Pacific.

Description: — A large species, the body of which is subbiconical in lateral outline, with well-rounded apices, and deepest at the girdle. The ratio between the length and the depth of the body is 1.35–1.40:1. The longitudinal axis has a very slight posteroventral inclination.

The epitheca is about as deep as the hypotheca, highest in the center, subconical, gently concave or almost straight dorsally and ventrally, evenly and well rounded anteriorly, with the dorsal, anterior, and ventral margins confluent, and very prominent above the anterior cingular list. The transverse furrow is somewhat concave, and its width is about 0.19 the greatest height of the epitheca. The posterior cingular list is about 0.43 the length of the body from the apex. The hypotheca has a very slight posteroventral inclination; its dorsal margin is gently concave or almost straight; its ventral margin is sigmoid, rather strikingly concave anteriorly, and gently and evenly convex posteriorly; its postmargin is evenly and fairly broadly convex, and confluent with the dorsal and ventral margins. In dorsoventral view the body is biconical, subacute anteriorly and narrowly rounded posteriorly; the side contours of the epitheca and hypotheca are gently concave; the ratio between the length and the width is about 1.45–1.50:1.

The cingular lists are subhorizontal, subequal, and about as wide as or somewhat wider than the transverse furrow; each of them has on each valve about twelve rather strong, branched, and nearly equidistant ribs. The sulcus is about 0.40 the length of the hypotheca. The flagellar pore is slightly more than a girdle-width behind the junction of the cingulum and the sulcus. On the ventral side of the left valve a rather small pore is found on the sagittal suture just in front of the anterior cingular list. The right sulcal list is about 0.22 the length of the body; the anterior half of this list is about 0.14 as wide as the body, and its free margin is gently concave or almost straight; the posterior half decreases gradually in width posteriorly, and its free margin is gently concave or nearly straight and forms a very wide but distinct angle with the free margin of the anterior half of this list. Two parasagittal lists encircle the body. The right one, which is much wider than the left, merges so completely into the left sulcal list that the boundary between these two lists cannot be established with certainty. For the sake of convenience in describing these structures, it is assumed that the first rib of this compound list behind the fission rib (easily recognized in the type specimen as it is split lengthwise) corresponds to the posterior main rib of the left sulcal list, and that it marks the posterior boundary of the last-mentioned list. Defined in this way, the left sulcal list is about as long as the right sulcal list, and has four

simple, and almost straight and equidistant ribs. Three of these ribs would correspond to the three main ribs; the fourth, which is placed between the anterior main rib and the fission rib, would be an accessory structure. The width of the left sulcal list is almost uniform throughout the entire length and about equals 0.14–0.15 the greatest depth of the body. From the posterior main rib of the left sulcal list to the antapex, the right parasagittal list is of nearly uniform width, about 0.14–0.20 the greatest depth of the body; anterodorsally to the antapex this list gradually becomes narrower, and its average width on the dorsal side of the hypotheca is only about 0.07 the greatest depth of the body. The right parasagittal list of the hypotheca has about twenty-six fairly strong and almost equidistant ribs, most of which are simple and almost straight, a few irregular, or irregular and branched. The left parasagittal list of the hypotheca extends from the fission rib of the left sulcal list to the posterior cingular list on the dorsal side of the body; it is very narrow, at most about half as wide as the transverse furrow; its ribbing is unknown. The two parasagittal lists of the epitheca are of about the same width and structure; from the apex, where their width about equals 0.09 the greatest depth of the body, they slightly decrease in width toward the girdle; each of them has about twenty almost equidistant ribs, a few of which are branched.

The thecal wall has a heavy reticulum of rather large polygons, mainly subuniform, ten of which on each valve border the posterior margin of the girdle. Each valve of the epitheca has about forty and each valve of the hypotheca about sixty-seven polygons. The transverse furrow is divided by cross-ridges into rectangular fields, of which there are about twelve or thirteen on each valve. The whole theca has numerous scattered pores, about ten to twenty in each polygon. On the left valve of the hypotheca there is the unique feature of a large postcingular plate, bordered by a heavy ridge (Plate 2, fig. 1).

The type specimen is megacytic.

The dimensions of the type specimen were measured.

Dimensions: — Length of body, 118 μ (140 μ, with the parasagittal lists included). Greatest depth of body, 83 μ.

Comparisons: — The systematic position of *Phalacroma fimbriatum* is somewhat uncertain. In the size of the body, the shape of the body in dorsoventral view, and in the structural differentiation of the thecal wall, both in the reduction in number of polygons, and in the increase in their size and in the weight of the reticulations, this species is one of the most advanced members of the genus, and with regard to the development of the parasagittal lists it may be considered as

the most advanced in the genus. On the other hand, in the position of the girdle it is very primitive. Its closest structural relatives possibly may be *P. reticulatum* and *P. turbineum;* see these two species, the sections on comparisons (p. 197, 200). These three species differ strikingly from one another in the shape of the body in lateral view and in the parasagittal lists.

With regard to the possible relationship between *Phalacroma fimbriatum* and *P. praetextum,* see p. 191.

Occurrence: — *Phalacroma fimbriatum* has been recorded at only one (4613, the type locality) of the 127 stations, on the first line of the Expedition, in the Panamic Area, from 300–0 fathoms, at a surface temperature of 80°. The frequency is less than 1% (one specimen).

Phalacroma reticulatum Kofoid

Plate 4, fig. 3, 5. Figure 25: 2; 26

Phalacroma reticulata Kofoid, 1907a, p. 195, pl. 12, fig. 72. Kofoid & Michener, 1911, p. 291. Pavillard, 1923a, p. 879.

Diagnosis: — Body biconical in lateral view, narrowly rounded anteriorly, narrowly rounded to subacute posteriorly, deepest at girdle, 1.25–1.30 times deeper than long. In dorsal view biconical, subacute anteriorly, acute posteriorly, and 1.65 times longer than wide. Posterior cingular list 0.40–0.45 the length of body from apex. Cingular list somewhat narrower than transverse furrow and apparently without ribs. Left sulcal list about 0.33 the length of the body; fairly narrow; its maximum width is 0.08 the greatest depth of body; with one rib near posterior end; free edge gently sigmoid, concave anteriorly and convex posteriorly. With a narrow parasagittal list on the hypotheca; this list forms a direct continuation of left sulcal list and extends to posterior cingular list. Theca with heavy and wide-meshed reticulation; about seven or eight polygons border girdle posteriorly. Length, 100–115 μ.

Eastern tropical Pacific.

Description: — A rather large species, the body of which is biconical, top-shaped in lateral outline, narrowly rounded anteriorly, subacute to acute posteriorly, and deepest at the girdle. The ratio between the length and the depth of the body is 1.25–1.30: 1. The longitudinal axis is about perpendicular to the girdle or but slightly deflected posteroventrally.

The epitheca is about as deep as or but slightly deeper than the hypotheca, highest in the center, and very prominent above the anterior cingular list; its dorsal and ventral margins are almost straight or gently convex, and about per-

pendicular to each other; anteriorly the epitheca is narrowly rounded. The transverse furrow is flat or somewhat convex or concave, and its width is 0.15–0.20 the greatest height of the epitheca. The posterior cingular list is 0.40–0.45 the length of the body from the apex. The hypotheca is conical, narrowly rounded or even subacute (Figure 25: 2) posteriorly; its dorsal margin (from the girdle to the antapex) is slightly and evenly convex or almost straight; its ventral margin (from the girdle to the antapex) is either gently and almost evenly convex, or it is gently undulating, concave anteriorly and posteriorly, and convex in the middle (Figure 25: 2). In dorsoventral view the body is biconical, top-shaped, widest at the girdle, and 1.65 times wider than long; anteriorly it is narrowly rounded, posteriorly it is acute; the side contours of the epitheca are almost straight and nearly perpendicular to each other; those of the hypotheca are gently sigmoid, concave anteriorly and convex posteriorly.

The cingular lists are subhorizontal, subequal, somewhat narrower than the transverse furrow, and apparently without ribs. The sulcus is about half as long as the hypotheca. The right sulcal list is low, extends to the posterior rib of the left sulcal list, and is reticulated posteriorly. The left sulcal list is about 0.33 the length of the body, and fairly narrow, its maximum width being about 0.08 the greatest depth of the body; its free edge is gently sigmoid, concave anteriorly and convex posteriorly. Near its posterior end this list has a short, straight, and simple rib of moderate strength; with the exception of this rib, this list appears to lack structural differentiation. On the right valve of the hypotheca there is a narrow parasagittal list, which forms a direct continuation of the left sulcal list and extends to the posterior cingular list; this parasagittal list is of almost uniform width throughout, somewhat narrower than the cingular lists, and is furnished with a moderate number (15–20) of simple ribs. There are no accessory lists or sails on the left valve of the hypotheca and on the epitheca.

The thecal wall has a heavy reticulum of relatively large polygons. Generally speaking, the polygons increase in size from the two apices toward the girdle, and on each valve about seven or eight of them border the posterior margin of the girdle. Each valve of the epitheca has a total of about twenty-four and each valve of the hypotheca about thirty-five to forty polygons. The transverse furrow is divided by cross-ridges into a number of rectangular fields, about ten fields on each valve. Pores were not seen.

Megacytic stages were not recorded.

The dimensions of two specimens were measured.

Dimensions: — Length of body, 100–115 μ (type, 100 μ). Greatest depth of body, 77–84 μ (type, 77 μ).

Variations: — The shape of the hypotheca is rather variable. In some specimens the hypotheca is subacute posteriorly, and its ventral margin (from the girdle to the antapex) is gently undulating, concave anteriorly and posteriorly, and convex in the middle. In other specimens the hypotheca is narrowly rounded posteriorly, and its ventral margin is gently and almost evenly convex.

Comparisons: — The structurally closest-known relative of *Phalacroma reticulatum* is *P. turbineum*. This relationship is especially indicated by the biconical, top-like shape of the body, by the heavy and coarse reticulation of the

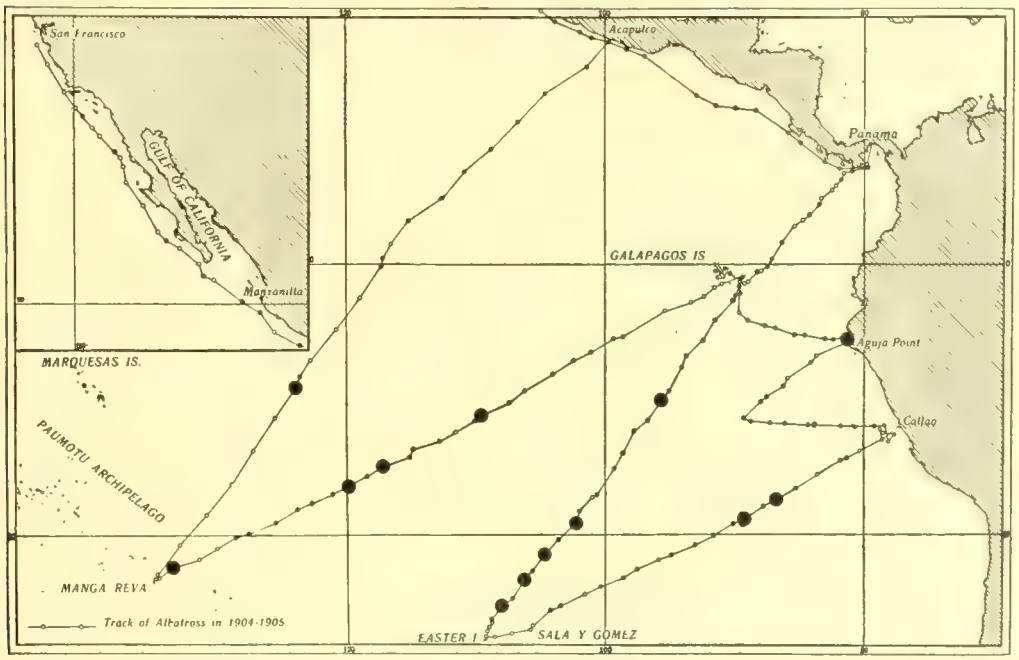

FIGURE 26.— Occurrence of *Phalacroma reticulatum* Kofoid. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

thecal wall, and by the presence of parasagittal lists. *Phalacroma reticulatum* is more advanced than *P. turbineum* in size, but in most other characters it appears to be more primitive; for instance, its body is relatively deeper, its hypotheca is relatively shorter, the reticulation of its thecal wall is less coarse, and it has only one parasagittal list on the hypotheca, while *P. turbineum* has two such lists on the epitheca as well as on the hypotheca.

Phalacroma fimbriatum may be fairly closely related to *P. reticulatum*. This relationship, which is less evident than that mentioned in the last paragraph, is indicated by the biconical, top-like shape of the body in dorsoventral view, by the heavy reticulation of the thecal wall, and by the presence of parasagittal lists.

When compared with *P. fimbriatum*, *P. reticulatum* is less advanced with regard to the size of the body, and in the number, size, and structural differentiation of the parasagittal lists, and it is more advanced in the top-like shape of its body in lateral view, in the position of its girdle, and in the coarser reticulation of its thecal wall.

With regard to the possible relationship between *Phalacroma reticulatum* and *P. praetextum*, see the last species, the section on comparisons.

Occurrence: — *Phalacroma reticulatum* is recorded at thirteen of the 127 stations. There are 0, 1, 2, 5, 4, and 1 stations on the six lines of the Expedition. Of these thirteen stations, one (4655) is in the Peruvian Current; three (4695, 4697, 4699) in the Easter Island Eddy; nine (4679, 4681, 4701, 4709, 4724, 4730, 4732, 4739, 4740) in the South Equatorial Drift. At one station (4655) the species is recorded from 400–0 fathoms; at one (4681) from 800–0 fathoms and 300–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these thirteen stations at the surface was 68°–81°; the average was 74.4°.

At one station (4699) the frequency is 1%; in the remaining cases it is less.

The species was first recorded by Kofoid (1907a) from Station 4740 of the Expedition; it was found in the Mediterranean by Pavillard (1923a).

The most outstanding peculiarities of the distribution of this species in the Eastern Pacific are the absence of surface records and the fact that all the record stations except one are located either in the South Equatorial Drift or in the Easter Island Eddy.

Phalacroma turbineum Kofoid and Michener

Plate 2, fig. 3. Plate 4, fig. 1, 2. Figure 25: 3

Phalacroma turbinea Kofoid & Michener, 1911, p. 291.

Diagnosis: — Body biconical in lateral outline, rather broadly rounded anteriorly, narrowly rounded posteriorly; deepest at girdle, 1.84 times deeper than long. In dorsal view of similar shape but somewhat wider. Posterior cingular list about 0.23 the length of body from apex. Cingular lists about half as wide as transverse furrow, with few ribs. Right sulcal list with T-shaped rib. Left sulcal list small, 0.38–0.39 the length of body, and with maximum width 0.12–0.13 the greatest depth of body; free margin gently and evenly convex; with cross-rib somewhat in front of its middle and submarginal rib along its entire length. Two parasagittal lists encircle body; the one on right valve of hypotheca continues left sulcal list; maximum width about equaling that of cingular lists; with moder-

ate number of short ribs. Theca with heavy and very wide-meshed reticulum; five polygons border girdle posteriorly. Length, 69.5 μ.

Eastern tropical Pacific.

Description: — A medium-sized species, the body of which is biconical, top-shaped in lateral outline, rather broadly rounded anteriorly, narrowly rounded posteriorly, and deepest at the girdle. The ratio between the length and the depth of the body is about 1.84: 1. The longitudinal axis is about perpendicular to the girdle.

The epitheca is about as deep as the hypotheca, highest in the center, and very prominent above the anterior cingular list; its dorsal and ventral margins are almost straight, or gently concave or convex; anteriorly it is fairly broadly rounded. The transverse furrow is somewhat concave, and its width is about 0.40 the greatest height of the epitheca. The posterior cingular list is about 0.23 the length of the body from the apex. The hypotheca is elongated and conical; posteriorly it is narrowly rounded; its dorsal margin (from the girdle to the antapex) is gently undulating, convex anteriorly and posteriorly, and concave in the middle; its ventral margin (from the girdle to the antapex) also is gently undulating, but it is concave anteriorly and posteriorly and convex in the middle. In dorsoventral view the body has about the same shape as in lateral view, but it is somewhat wider; the ratio between the length and the width is about 1.50: 1; the side contours of the hypotheca are evenly and moderately concave.

The cingular lists are subhorizontal, subequal, about half as wide as the transverse furrow, and have a few (about seven or eight on each valve) simple, straight cross-ribs. The sulcus is relatively short, about 0.26 the length of the hypotheca. The flagellar pore is at the junction of the cingulum and the sulcus. A large pore is to be found in the transverse furrow, just in front of the flagellar pore. The right sulcal list is about 0.20 the length of the body, subtriangular, and decreases gradually in width posteriorly; its maximum width about equals half the width of the transverse furrow; along its entire free edge runs a marginal rib, from the middle of which arises a cross-rib to the base of the list. The left sulcal list is small; its length is 0.38–0.39 the length of the hypotheca, and its maximum width is 0.12–0.13 the greatest depth of the body; its free margin is gently and evenly convex; it has a weak cross-rib somewhat in front of its middle and a submarginal rib along its entire length; with the exception of these two ribs, this list appears to lack structural differentiation. Two parasagittal lists encircle the body; the one on the right valve of the hypotheca forms a direct continuation of the left sulcal list. On the average the parasagittal lists are about twice as wide

on the posterior half of the shell as on the anterior half, and their maximum width about equals that of the cingular lists; each of them has a moderate number of short, simple ribs, approximately six on the epitheca and eighteen on the hypotheca. On the ventral side of the body the distance between the two parasagittal lists about equals the width of the transverse furrow; on the dorsal side of the body it is about 2.5 times as wide at the girdle, and from the girdle it decreases gradually toward the apices.

The cingular and the parasagittal lists arise from narrow but well-marked ridges, which are connected by similar cross-ridges. These cross-ridges divide the transverse furrow and the zone between the parasagittal lists into rectangular fields. The number of rectangular fields in the transverse furrow is about seven or eight on each valve; most of these fields have a fine, central pore. The number of rectangular fields in the zone between the parasagittal lists is about five or six on the epitheca, and seventeen or eighteen on the hypotheca; in these fields no pores were found. The rest of the thecal wall has a heavy reticulum of very large polygons. Generally speaking, the polygons increase in size from the two apices toward the girdle, and on each valve five of them border the posterior margin of the girdle. Each valve of the epitheca has about ten, and each valve of the hypotheca about twenty-nine polygons. Pores were not seen in the polygons.

The nucleus is large and rounded; its diameter is about 0.5 the greatest depth of the body. It lies at the level of the girdle, is filled with beaded chromatin, and contains some spheroidal structures.

With regard to megacytic stages, see the section on comparisons, below.

The dimensions of the type specimen were measured.

Dimensions: — Length of body, 69.5 μ. Greatest depth of body, 37.8 μ.

Variations: — The two specimens were very similar.

Comparisons: — In the specimens of this species examined the two parasagittal lists are separated from the sagittal suture by a broad zone. In premegacytic specimens of other species of this genus with two parasagittal lists, these lists are located near the sagittal suture (*cf. P. limbatum*, Plate 3, fig. 3); in megacytic specimens of these species on the other hand, they are separated from this suture by the broad intercalary zone (*cf. P. fimbriatum*, Plate 2, fig. 1). The zone between the parasagittal lists in *P. turbineum* has the same position, relative size, and shape (being wider on the dorsal side of the body than on the ventral) as the intercalary zone. On the other hand, it has not the juvenile structural appearance that usually characterizes the intercalary zone but is furnished with cross-ridges which are as well developed as the ridges on the remaining portion of the thecal

wall. For this reason we consider the question open as to whether or not the Expedition specimens are megacytic.

This beautiful and characteristic species is structurally most closely related to *Phalacroma reticulatum* (see p. 197). It may also be fairly closely related to *P. fimbriatum*, but this relationship is less evident. The last two species resemble each other in the biconical, top-like shape of the body in dorsoventral view, in the development of two parasagittal lists extending around the body, and in the heavy reticulation of the thecal wall. *Phalacroma fimbriatum* is much more advanced than *P. turbineum* in the size of the body and in the size and structural differentiation of the parasagittal lists. On the other hand, *P. turbineum* is more advanced than *P. fimbriatum* in the elongated, conical shape of the hypotheca seen in lateral view, in the position of the girdle, and in the coarser reticulation of the thecal wall. Indeed, the polygons of the thecal reticulation are relatively larger than in any other known species of this genus.

With regard to the possible relationship between *Phalacroma turbineum* and *P. praetextum*, see p. 191.

Occurrence: — *Phalacroma turbineum* is recorded at two of the 127 stations. One of these two stations (4681) is on the third line of the Expedition and in the South Equatorial Drift; the other (4715) is on the fourth line and in the Galapagos Eddy. Both records refer to hauls from 300–0 fathoms.

The temperature of these two stations at the surface was 68° and 75°, respectively; the average was 71.5°.

The frequency is less than 1% (one specimen at each station).

Dinofurcula, gen. nov.

Phalacroma Kofoid, *partim* (1906c, 1907a).

Diagnosis: — Body molariform in lateral outline, with two long, narrow, and acute to narrowly rounded posterior processes; strongly compressed bilaterally; its length 1.57–1.83 the depth of midbody. Epitheca 0.62–0.78 the greatest depth of midbody, low. Transverse furrow narrow, of subuniform width throughout, and gently concave to flat. Posterior cingular list 0.14–0.26 the length of body from apex. Shortest distance from curvature between posterior processes to posterior cingular list 0.26–0.61 the greatest depth of midbody. Distance between tips of posterior processes 0.80–0.93 the greatest depth of midbody. Cingular lists subhorizontal, subequal, slightly wider to slightly narrower than transverse furrow, and ribbed. Sulcal lists about as wide as or somewhat narrower than the cingular.

TYPE. — *Dinofurcula ultima* Kofoid.

Distribution: — Up till the present time, species of this planktonic genus have been found only in the eastern warm-temperate and tropical Pacific.

Representatives of Dinofurcula are recorded at six of the 127 stations of the Expedition. Four of these six stations (4655, 4659, 4661, 4671) are within the

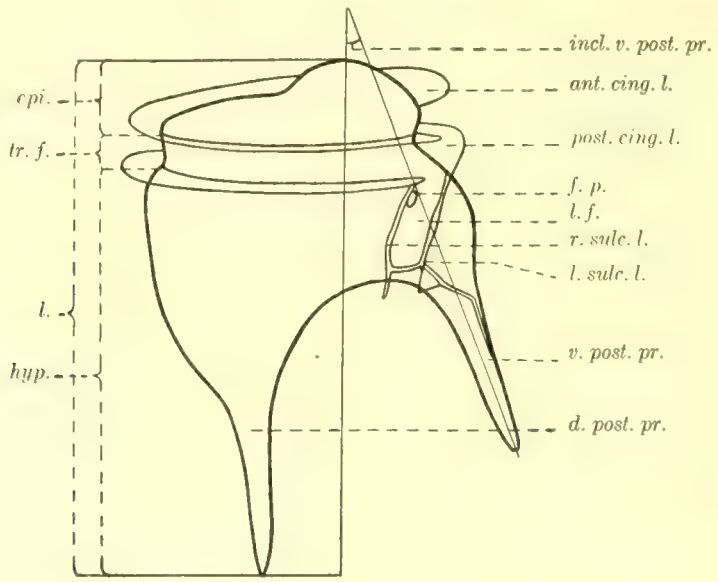

FIGURE 27.— Diagram of measurements in Dinofurcula. Measurements are made in straight lines. Proportions are measured as if all parts were in the same plane, *i.e.*, as they appear in drawings. Longitudinal axis of body is perpendicular to girdle. The length of body is distance between the two perpendiculars to longitudinal axis that pass through apex of body and tip of dorsoposterior process. The depth of body is measured perpendicularly to longitudinal axis. The greatest height of epitheca is the shortest distance from apex of body and base of anterior cingular list. The depth of epitheca is measured along base of anterior cingular list. The width of transverse furrow and of cingular lists is measured dorsally. The position of posterior cingular list is expressed in the ratio between the shortest distance from apex of body to the mentioned list and the length of body. The inclinations of the posterior processes are the angles between the longitudinal axis of the body and the long axis of these processes.

Abbreviations: — *ant. cing. l.*, anterior cingular list; *d. post. pr.*, dorsoposterior process; *epi.*, epitheca; *f.p.*, flagellar pore; *hyp.*, hypotheca; *incl. v. post. pr.*, inclination of ventroposterior process; *l.*, length of body; *l. f.*, longitudinal furrow; *l. sulc. l.*, left sulcal list; *post. cing. l.*, posterior cingular list; *r. sulc. l.*, right sulcal list; *tr. f.*, transverse furrow; *v. post. pr.*, ventroposterior process.

Peruvian Current; two (4681, 4711) are outside this current, but undoubtedly within its sphere of influence.

The genus has not been found as yet in the surface waters. All the records refer to hauls from 300 (400, 800)–0 fathoms. Data based on hauls made with closing nets are not available.

Both the species known seem to be rare. The frequency is less than 1% at all the six stations mentioned.

Dinofurcula ultima (Kofoid)

Plate 5, fig. 4, 6. Figure 28: 1

Phalacroma ultima Kofoid, 1906c, p. 95; 1907a, p. 195, pl. 12, fig. 68.

Diagnosis: — Body broadly molariform in lateral view; its length 1.57–1.60 the greatest depth of midbody. Epitheca 0.78 the greatest depth of midbody; with rounded ventral hump, which is somewhat higher than width of transverse furrow. Ventroposterior process inclined posteroventrally at 21°–23°. Sulcus runs on right face of body and extends to dorsal side of base of ventroposterior process. Except on posterior processes, theca is finely reticulated. Length, 61.3–63.6 μ.

Eastern tropical and subtropical Pacific.

Description: — A medium-sized and rather broad species, the body of which is molariform in lateral outline. The ratio between the length of the body and the greatest depth of the midbody is 1.57–1.60: 1. The epitheca is about 0.78 as deep as the midbody; dorsally it is low, but ventrally it forms a large rounded hump, which includes the ventral half of the epitheca and is about twice as high as the width of the transverse furrow or somewhat less. The transverse furrow, which is concave, forms a descending left spiral, and its distal end is displaced posteriorly about half its width. The posterior cingular list is about 0.24 0.26 the length of the body from the apex. The hypotheca is deepest just behind the girdle. The dorsal margin is rather strikingly sigmoid, being gently convex, almost straight or even slightly concave anteriorly (Figure 28: 1), and moderately concave posteriorly. The ventral margin is also sigmoid, being gently to moderately convex anteriorly and slightly concave posteriorly. The posterior processes are almost straight, slender, slightly tapering, and subacute distally; the ventral one is inclined posteroventrally at about 21°–23°; the dorsal either is subparallel to the longitudinal axis of the body or it has a slight posteroventral inclination. The curvature between the posterior processes is comparatively deep and broad, and the shortest distance between this curvature and the posterior cingular list is about 0.26–0.29 the greatest depth of the midbody and 0.13–0.16 the length of the body. The distance between the tips of the posterior processes is 0.80–0.86 the greatest depth of the midbody. In dorsoventral view the ventroposterior process is inclined to the right; the two posterior processes diverge from each other at an angle of about 20°. The greatest transdiameter of the body is located just behind the transverse furrow and equals about 0.38 the greatest dorsoventral diameter of the midbody.

The cingular lists are subhorizontal, subequal, and about as wide as or somewhat wider than the transverse furrow; each of them has on each valve about fifteen to seventeen straight, simple, and almost equidistant ribs. The sulcus runs on the right face of the body toward the dorsal side of the base of the ventroposterior process; it extends to the posterior margin of the midbody, and is nearly as wide as the transverse furrow. The flagellar pore is located just behind the girdle on the right (dorsal) side of the sulcus. The right (dorsal) margin of the sulcus has a low ridge or list, which continues as a short spine beyond the postmargin of the midbody. The left sulcal list extends to the posterior end of the sulcus and is throughout its entire length about as wide as the posterior cingular list; posteriorly it is rectangular (Plate 5, fig. 6); its structure is unknown.

Except on the posterior processes, the thecal wall is finely reticulate. The meshes are subequal and irregular, and on each valve about thirty-five to forty-five meshes border the girdle anteriorly. The suture between the valves seems to follow the left sulcal list to a point near the postmargin of the midbody, from whence it turns abruptly toward the ventral margin of the ventroposterior process.

The dimensions of two specimens were measured.

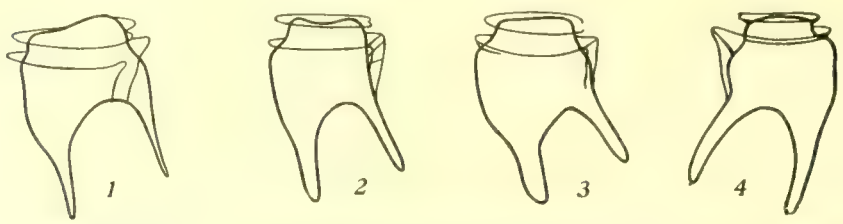

FIGURE 28.— 1, *Dinofurcula ultima* (Kofoid), right lateral view. × 430. Station 4661 (300–0 fathoms). 2, 3, 4, *Dinofurcula ventralis*, gen. et spec. nov. 2, 3, in right lateral view; 4, left lateral view of type specimen. × 430. 2, from Station 4659 (300–0 fathoms); 3, from Station 4655 (400–0 fathoms); 4, from Station 4681 (800–0 fathoms).

Dimensions: — Length of body, 61.3–63.6 μ (type, 61.3 μ). Greatest depth of midbody, 39.0–39.7 μ (type, 39.0 μ). Distance between tips of posterior processes, 32.3–34.0 μ (type, 34.0 μ).

Variations: — The specimens examined are strikingly similar.

Comparisons: — *Dinofurcula ultima* is easily distinguished from *D. ventralis* by having a large, rounded hump on the ventral side of the epitheca and by the lateral position of the sulcus.

Occurrence: — *Dinofurcula ultima* is recorded at three of the 127 stations. There are 0, 2, 0, 1, 0, and 0 stations on the six lines of the Expedition. Of these three stations, two (4661, 4671) are in the Peruvian Current, and one (4711) is in the South Equatorial Drift. All the records refer to hauls from 300–0 fathoms.

The temperature range of these three stations at the surface was 66°–75°; the average was 70.0°.

The frequency is in all the cases less than 1%.

Dinofurcula ventralis, sp. nov.

Figure 28: 2, 3, 4

Diagnosis: — Body rather narrowly molariform in lateral view; its length 1.60–1.83 the greatest depth of midbody. Epitheca 0.62–0.74 the greatest depth of midbody, lower than transverse furrow, not, or but slightly higher ventrally than dorsally. Ventroposterior process inclined posteroventrally at 30°–36°. Sulcus runs along ventral margin of midbody to ventral side of base of ventroposterior process. Length, 56.5–60.7 μ.

Eastern tropical and subtropical Pacific.

Description: — A medium-sized and rather narrow species, the body of which is molariform in lateral outline. The ratio between the length of the body and the greatest depth of the midbody is 1.74 (1.60–1.83): 1. The epitheca is relatively narrow, 0.68 (0.62–0.74) as deep as the midbody, and low, 0.45–0.80 the width of the transverse furrow; sometimes (Figure 28: 4) it is gently convex and highest in the center, sometimes (Figure 28: 3) flattened and highest ventrally, and sometimes (Figure 28: 2) gently concave in the middle and of equal height dorsally and ventrally. The transverse furrow is concave, and, according to available data, its distal end is not displaced posteriorly. The posterior cingular list is 0.18 (0.14–0.22) the length of the body from the apex. The greatest depth of the hypotheca is variable in position; sometimes it is located near the middle of the midbody, sometimes near the bases of the posterior processes, and sometimes near the distal ends of these processes. The dorsal margin either (Figure 28: 2, 3) is sigmoid, being gently convex or almost straight anteriorly and gently to moderately concave posteriorly; or it is (Figure 28: 4) gently undulating. In some specimens (Figure 28: 2) the ventral margin is gently and almost evenly concave; in others (Figure 28: 3, 4) it is more or less strikingly convex anteriorly. The posterior processes sometimes are almost straight, and sometimes (Figure 28: 4) slightly curved toward each other. The ventral of them, which usually is very slender, tapers very slightly and is subacute to more or less rounded distally. The dorsal one, usually somewhat wider than the ventral, also is somewhat tapering, and subacute to more or less rounded distally; in one specimen (Figure 28: 3) the average width of this process about equaled the width of the transverse furrow, but usually it is somewhat less. The ventroposterior process is inclined

posteroventrally at about 30°–36°; the dorsoposterior either is subparallel to the longitudinal axis of the body, or it has a slight posteroventral inclination. In one specimen, the type, the tip of each of these processes had a very small spinule. The curvature between the posterior processes is fairly deep and wide, and the shortest distance between this curvature and the posterior cingular list is 0.53 (0.47–0.61) the greatest depth of the midbody and 0.30 (0.28–0.33) the length of the body. The distance between the tips of the posterior processes is 0.88 (0.80–0.93) the greatest depth of the midbody.

The cingular lists are subequal, somewhat narrower than the transverse furrow, and subhorizontal or somewhat inclined anteriorly; their structure is unknown. The sulcus runs on the right face of the body, near the ventral margin, to the ventral side of the base of the ventroposterior process. The extension and width of the right sulcal list are unknown. The left sulcal list extends to the posterior end of the sulcus; anteriorly it is about as wide as or even somewhat wider than the transverse furrow, and it decreases gradually in width posteriorly; its structure is not known with entire certainty, but it appears to have one to three ribs in its anterior half. The structure of the theca is unknown.

The dimensions of three specimens were measured.

Dimensions: — Length of body, 56.6–60.7 μ (average, 58.4 μ; type, 60.7 μ). Greatest depth of midbody, 31.1–36.0 μ (average, 33.6 μ; type, 33.7 μ). Distance between tips of posterior processes, 28.8–31.1 μ (average, 29.6 μ; type, 31.1 μ).

Variations: — While *Dinofurcula ultima* appears to be fairly constant in size and structure, this species is comparatively variable. The following characters are the most variable: the depth and the shape of the epitheca, the depth of the midbody, the shape of the ventral margin of the hypotheca, and the width of dorsoposterior process.

Comparisons: — This species is established on outline drawings of three specimens in lateral view. The shape of the body in dorsoventral view, the structure of the cingular lists and of the theca are unknown, and knowledge of the sulcal lists is incomplete. The species is readily distinguished from *Dinofurcula ultima* by the lack of the large ventral hump on the epitheca and by the ventral position of the sulcus.

Occurrence: — *Dinofurcula ventralis* is recorded at three of the 127 stations. There are 0, 2, 1, 0, 0, and 0 stations on the six lines of the Expedition. Of these three stations, two (4655, 4659) are in the Peruvian Current, and one (4681), the type locality, is in the South Equatorial Drift. The depth records are 400, 300, and 800 fathoms to the surface, respectively.

The temperature range of these three stations at the surface was 65°–69°; the average was 67.3°.

The frequency is in every case less than 1%.

Dinophysis Ehrenberg

Dinophysis Ehrenberg, 1840a, p. 124. Griffith & Henfrey, 1856, p. 211. Diesing, 1866, p. 98. Fromentel, 1874, p. 196. Kent, 1881, p. 458. Bergh, 1881b, p. 226. Bütschli, 1885, p. 941, 1010. Delage & Hérouard, 1896, p. 385. Schütt, 1896, p. 27. Paulsen, 1908, p. 12. Meunier, 1919, p. 79. Jörgensen, 1923, p. 18. Lebour, 1925, p. 79.
Dynophysis Van Oye, 1921, p. 209, 212, 214 (*lapsus pennae*).

Diagnosis:—Body usually subovate, subcircular, subellipsoidal, subobovate, subreniform, subtrapeziform, or subtrapezoidal in lateral outline, or very elongated with one or two posterior peduncles; ratio between length and depth usually somewhere between 1.1 : 1 and 1.6 : 1 but may be as low as 0.97 : 1 or as high as 5.3 : 1; on the whole somewhat more compressed bilaterally than in Phalacroma. Epitheca always low, as evidenced by the fact that posterior cingular list is never more than 0.28 the length of body from apex; ratio between its depth and depth of hypotheca 0.30–0.86 : 1. Transverse furrow narrow, of subuniform width throughout, flat or but slightly convex or concave; its width subequal to or but slightly greater or smaller than height of epitheca. Cingular lists may be subhorizontal but usually with more or less pronounced anterior inclination; anterior 1.0–4.0 the width of transverse furrow and sometimes ribbed; posterior usually somewhat narrower than anterior and without ribs in most species. Right sulcal list small, usually subtriangular, and ends at or slightly in front of or behind R_2 of left sulcal list. Left sulcal list usually subtrapeziform, somewhat wider posteriorly than anteriorly, with pronounced posteroventral angle, and with three ribs, one (R_1) in front and one (R_3) behind fission rib (R_2); R_2 somewhat behind girdle; length of this list ranges from 0.41 to 0.84 the length of hypotheca; R_2 usually 0.20–0.35, seldom as little as 0.11 or as much as 1.25 the depth of body; for R_3 the corresponding values are 0.30–0.60 and 0.00, 1.33; margin seldom rounded posteroventrally. Sometimes with accessory lists and sails.

Type. — *Dinophysis acuta* Ehrenberg.

Organology: — The *body* (*theca*) in Dinophysis is diverse in shape; usually, however, its shape is fairly simple, and only in one group of species, *viz.*, in the Caudata group, does it show pronounced elongation and protuberances. When seen laterally, it generally is somewhat asymmetrical, but symmetrical species

also have been recorded (*e.g.*, *D. sphaerica*, Figure 31:3). In dorsoventral view it appears always to be symmetrical. Sometimes (*D. triacantha*, Figure 42:2) the *longitudinal axis* (*l.a.*, Figure 29) is perpendicular to the girdle, but in most species it is inclined either posterodorsally or posteroventrally. While in Phalacroma only one species has been recorded as yet in which this axis is inclined posterodorsally, this inclination is found rather frequently in Dinophysis. In the species with the most pronounced posterodorsal deflection of this axis, viz., *D. collaris* (Plate 5, fig. 2), an inclination of 10°–15° was found. The maximum posteroventral inclination as yet established is 30° (*D. caudata*, Figure 44). The inclination is very variable even within the species.

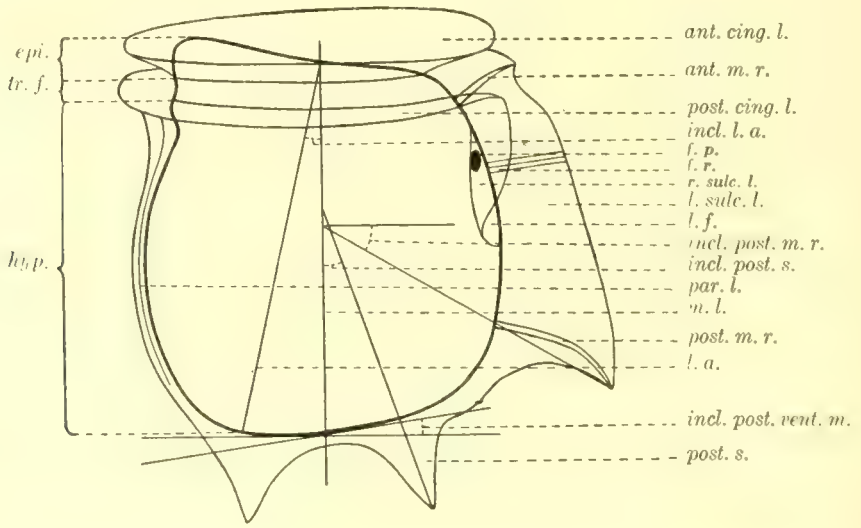

FIGURE 29. — *Dinophysis collaris* Kofoid and Michener, right lateral view. Station 4671 (300–0 fathoms). Terminology and methods of making measurements of Phalacroma and Dinophysis.

Terminology: — The midline is the perpendicular to girdle which is equidistant from dorsal and ventral margins of body at place of greatest depth of body. When longitudinal axis of body is not inclined, it coincides with midline. In specimen represented by this Figure the longitudinal axis of body is inclined *posterodorsally* and the posteroventral margin of body, *dorsoposteriorly*, according to our terminology. The anterior main rib (R_1) is the rib at junction of left sulcal list and posterior cingular list. The fission rib (R_2) is the rib of left sulcal list at place where this list is divided in binary fission. The posterior main rib (R_3) is the rib of left sulcal list near posterior end of this list or, in the case of two or more ribs in this region, the best developed of these. Ventral margin of left sulcal list is the free edge of this list between R_1 and R_3; posterior margin of this list is the free edge behind R_3.

Methods of making measurements: — Measurements are made in straight line, if not otherwise stated. Proportions of theca are measured as if all parts were in the same plane, *i.e.*, as they appear in drawings. The length of body is the distance from apex to antapex. The depth of body is measured parallel to girdle. The inclination of longitudinal axis of body is the angle between this line and midline. The greatest height of epitheca is the shortest distance between apex and base of anterior cingular list. The depth of epitheca is measured along base of anterior cingular list. The width of transverse furrow is measured along dorsal outline, when body is seen in lateral view. The length of longitudinal furrow is measured from posterior cingular list. The inclination of posteroventral margin of body is the angle between this margin and a line parallel to girdle. The widths of cingular lists are measured dorsally, when organism is seen in lateral

view. The inclination of these lists is the angle between their dorsal margin and a line perpendicular to midline. The position of posterior cingular list is expressed in the ratio between the shortest distance from apex to the mentioned list and the length of body. The length of left sulcal list is measured from the base of R_1 to the posterior point of base of this list; if R_1 is absent and if this list is continued by parasagittal list, the measurement is made from the posterior cingular list to the base of R_3. The inclination of R_3 is the angle between a line parallel to girdle and the line through tip and base of R_3. The length of posterior sail is measured from the tip to the middle of base of this structure. The inclination of posterior sail is the angle between the midline and the line through the tip and the middle of base of posterior sail.

Abbreviations: — *ant. cing. l.*, anterior cingular list; *ant. m. r.*, anterior main rib; *epi.*, epitheca; *f. p.*, flagellar pore; *f. r.*, fission rib; *hyp.*, hypotheca; *incl. l. a.*, inclination of longitudinal axis; *incl. post. m. r.*, inclination of posterior main rib; *incl. post. s.*, inclination of posterior sail; *incl. post. vent. m.*, inclination of posteroventral margin; *l. a.*, longitudinal axis; *l. f.*, longitudinal furrow; *l. sulc. l.*, left sulcal list; *m. l.*, midline; *par. l.*, parasagittal lists; *post. cing. l.*, posterior cingular list; *post. m. r.*, posterior main rib; *post. s.*, posterior sail; *r. sulc. l.*, right sulcal list; *tr. f.*, transverse furrow.

When seen laterally, the *body* usually is longer than deep; in only a few species specimens are found, the body of which is deeper than long. In the species with the most elongated body (*Dinophysis miles* Cleve, 1900b, fig. 1b), the ratio between the length and the depth is about 5.3:1 (the depth being measured just behind the dorsal peduncle); in the species with the relatively deepest body (*D. triacantha*, Figure 42:2), the corresponding ratio is about 0.97:1; in most species it is between 1.1:1 and 1.6:1. Sometimes the body is deepest in or near the middle, but usually the greatest depth has shifted posteriorly; only in exceptional cases (*D. caudata*, Figure 44:3) the greatest depth is located in front of the middle.

In most species the *body*, seen laterally, is ovate or subovate; in some of these it is relatively deep, almost subcircular (*Dinophysis jörgenseni*, Figure 42:6), in others more or less elongated (*D. fortii*, Figure 31:7). The following shapes of body, seen laterally, have also been found: — subcircular (*D. triacantha*, Figure 42:2); ellipsoidal or subellipsoidal (*D. similis*, Figure 31:2); subovate, truncate anteriorly (*D. uracantha*, Figure 35:3); asymmetrically subovate, flattened ventrally (*D. sacculus*, Stein, 1883, pl. 20, fig. 12); subovate, with a dorsal shoulder-like constriction at the girdle and with the ventral margin somewhat concave between the epitheca and the fission rib of the left sulcal list (*D. okamurai*, Figure 31:5); obovate (*D. alata*, Jörgensen, 1923, fig. 45); subobovate with the posterior end acute or subacute (*D. acuta*, Stein, 1883, pl. 20, fig. 13); short sausage-shaped and straight or gently sigmoid (*D. sacculus*, Stein, 1883, pl. 20, fig. 10, 11); reniform (*D. reniformis*, Pavillard, 1905, pl. 3, fig. 10); elongated, subacute posteriorly, with the dorsal margin evenly convex, and with the ventral margin more or less angular at the posterior main rib of the left sulcal list and fairly straight in front of this rib (*D. schröderi*, Figure 31:6); subtrapeziform, protracted posterodorsally (*D. trapezium*, Figure 38:2); rounded sub-

trapeziform or pitcher-shaped (*D. monacantha, D. urceolus*, Figure 37); narrowly subtrapezoidal (*D. dens*, Pavillard, 1916, pl. 3, fig. 1); very elongated, with the anterior portion of the body irregularly ovate and the posterior portion pedunculate (*D. caudata*, Figure 44); very elongated, with the anterior portion of the body irregularly ovate and the posterior portion pedunculate, and with a more or less developed peduncle near the middle of the dorsal side of the body (*D. tripos*, Jörgensen, 1923, fig. 38; *D. miles*, Cleve, 1900b, fig. 1). Between these shapes transitions are to be found. It also should be mentioned in this connection that the lateral outline of the body often is strikingly variable even within the species; the most extreme examples of such variations are to be found in *D. caudata* (Jörgensen, 1923, fig. 30–37).

The *body* is compressed bilaterally in all the species in which the dorsoventral outline is known; it should be remembered, however, that this character has not been recorded as yet in most of the species. Sometimes the compression is moderate, *e.g.*, in *Dinophysis schütti*, in which the ratio between the length and the transdiameter is about 1.45: 1; sometimes it is very pronounced as in *D. collaris* (Plate 5, fig. 2, 8) and *D. caudata* (Stein, 1883, pl. 21, fig. 1, 7), in which this ratio is about 3: 1 and 7–8: 1, respectively. The dorsoventral outline usually is narrowly ovate, ellipsoidal (*D. schütti*, Figure 40: 7), or lenticular (*D. acuta*, Stein, 1883, pl. 20, fig. 17). When lenticular, its lateral contours sometimes are subparallel (Meunier, 1919, pl. 3, fig. 40, 48) or even slightly concave (*D. schröderi*) in the middle. Sometimes (*D. collaris*, Plate 5, fig. 8) it is narrowly obovate with the side contours almost straight and gently converging posteriorly; sometimes (*D. caudata*, Stein, 1883, pl. 21, fig. 6, 7) the side contours are subparallel anteriorly and gently converging posteriorly. A cuneate outline has been found in one species only, viz., in *D. cuneiformis* (Meunier, 1910, pl. 14, fig. 32), in which it is widest at the girdle and acute posteriorly. This circumstance is especially noteworthy since a cuneate dorsoventral outline is fairly frequent in the closely related genus Phalacroma.

One of the most characteristic features of Dinophysis, when compared with Phalacroma, is the small size of the *epitheca* (*epi.*, Figure 29). The epitheca is always very low, which is evident from the fact that the posterior cingular list never is located farther from the apex than about 0.28 the length of the body (*Dinophysis exigua*, Figure 30); in most species this list is only about 0.10–0.20 the length of the body from the apex. Its depth does not exceed 0.86 the greatest depth of the hypotheca (*D. hastata*, Figure 33: 3) and sometimes (*D. schütti*, Figure 40: 5, 6) does not amount to more than 0.30 the greatest depth of the

hypotheca; in most species this ratio varies between 0.40:1 and 0.60:1. As a rule the greatest height of the epitheca is in or near the center, but sometimes it has shifted dorsally (*D. hastata*, Figure 33:1) or slightly ventrally (*D. uracantha*, Figure 35:2). The outline of the epitheca in lateral view usually is gently and almost evenly convex, but sometimes it is fairly strongly convex (*D. uracantha*, Figure 35:2), flat (*D. uracantha*, Figure 35:3), or even gently concave (*D. collaris*, Plate 5, fig. 2; *D. urceolus*, Figure 37:1). In most species the epitheca is not visible, in lateral view, above the anterior cingular list; sometimes (*D. collaris*, Plate 5, fig. 2) it is barely visible.

In consequence of the small height of the epitheca, the *transverse furrow* (*tr.f.*, Figure 29) is always situated near the anterior end of the body. Its distal portion is not displaced posteriorly, *i.e.*, it does not form a spiral about the body; and it always crosses the lateral faces of the body in an almost straight line. Its width is moderate and subject to but slight variations, being either subequal to or somewhat greater or slightly smaller than the greatest height of the epitheca. Its floor is flat or but slightly concave or convex.

The length of the *longitudinal furrow* is unknown in most species, but judging by the length of the right sulcal list it usually does not exceed 0.3 the length of the hypotheca. Only in exceptional cases (*Dinophysis ellipsoides* Kofoid, 1907b, pl. 33, fig. 56) this furrow is as long as 0.55 the length of the hypotheca. Anteriorly it does not extend beyond the girdle, *i.e.*, into the epitheca, and it is at most but slightly impressed.

The *lists of the furrows* are not excessively developed. They arise from low and narrow basal ridges (Plate 5, fig. 3, 7), and are hyaline and generally exceedingly delicate.

In some species the *cingular lists* (*ant. cing. l.*, *post. cing. l.*, Figure 29) are subequal, but usually the width of the anterior exceeds that of the posterior; frequently this difference is fairly slight, but the anterior may be several times wider than the posterior (*Dinophysis okamurai*, Figure 31:5). The anterior may be open or closed ventrally; the posterior is always open ventrally. The anterior cingular list usually is between 1.5 and 2.5 times wider than the transverse furrow and between 0.15 and 0.30 the greatest depth of the body. Sometimes, however, its width is subequal to that of the transverse furrow and only about 0.13 the greatest depth of the body (*D. hastata*, Figure 32:15); or it may be as much as 4.0 times the width of the transverse furrow and 0.50 the greatest depth of the body (*D. swezyi*, Plate 5, fig. 9; *D. schütti*, Figure 40:1). The posterior cingular list sometimes (*D. acuminata*, Jörgensen, 1923, fig. 25) is so reduced in width

that hardly anything but its basal ridge is present. In most species these lists are funnel-shaped, *i.e.*, inclined anteriorly at an angle of between 20° and 60°; but both of them may be subhorizontal (*D. monacantha*, Figure 37:2, 3). Their inclination either is about the same or, and this seems to be the rule, the inclination of the anterior slightly exceeds that of the posterior. It should be remembered, however, that the pressure of the cover-glass is likely to change the inclination of these lists. Sometimes (Pavillard, 1916, pl. 3) both these lists appear to lack structural differentiation, except for one or two ribs dorsally and ventrally on each valve near the sagittal suture; sometimes (*D. jörgenseni*, Plate 5, fig. 7) the posterior list is undifferentiated while the anterior is ribbed; sometimes (*D. collaris*, Plate 5, fig. 2) both of them are ribbed. The ribs usually are rather strong, straight, simple, and nearly equidistant; but they may be more or less irregular and branched (*D. jörgenseni*, Plate 5, fig. 7), or they may even anastomose into a reticulum (Stein, 1883, pl. 20, fig. 20); sometimes some of them are incomplete (Jörgensen, 1923, fig. 46, 47). When both lists are ribbed, the number of ribs in the anterior list is either subequal to or somewhat larger or smaller than that of the posterior. In most cases each list has on each valve between ten and twenty ribs, but as many as twenty-five have been observed (*D. hastata*).

The *sulcal lists*, which form a direct continuation of the posterior cingular list, run about parallel to each other on either side of the longitudinal furrow. The entire right sulcal list and the posterior portion of the left belong to the right valve, while the anterior portion of the left sulcal list belongs to the left valve.

The *right sulcal list* (*r. sulc. l.*, Figure 29) is subject to but slight differentiation. In most species it is rather constant in size and shape, but in some (*e.g.*, in *Dinophysis hastata*) it exhibits about the same range of variation as within the genus as a whole. Usually it extends to or slightly beyond the fission rib of the left sulcal list, and only exceptionally it is decidedly shorter (*D. pusilla*, Jörgensen, 1923, fig. 44) or extends as far back as to the posterior main rib of the left sulcal list (*D. ellipsoides*, Kofoid, 1907b, pl. 33, fig. 56). In most species it is subtriangular to rounded triangular, about as wide as the transverse furrow anteriorly, and decreasing gradually in width posteriorly. Sometimes (*D. hastata*, Figure 32:5, 9) it is of subuniform width throughout the greater portion of its length, fairly strongly rounded posteriorly, and about as wide as the transverse furrow anteriorly; sometimes it is gently sigmoid, concave anteriorly, convex posteriorly (*D. jörgenseni*, Figure 42:3). No structural differentiation has been observed. Its ventral margin is always free.

The *left sulcal list* (*l. sulc. l.*, Figure 29), on the other hand, shows a rather striking differentiation within the genus and is also fairly variable in some of the species (*Dinophysis swezyi*, Figure 39). For the sake of convenience in describing this list, it may first be mentioned that in nearly all the species it has three well-developed cross-ribs, which are named the anterior main rib, the fission rib, and the posterior main rib. The anterior main rib (*ant. m. r.*, Figure 29) is located anteriorly, at the junction of this list and the posterior cingular list; the fission rib (*f. r.*, Figure 29), at the place where the list is divided in binary fission, *i.e.*, at the sagittal suture and usually somewhat in front of the middle of the list; the posterior main rib (*post. m. r.*, Figure 29), near the posterior end of the list. Frequently the anterior main rib and the fission rib are subequal; when different, the fission rib usually is the longer, but sometimes (*D. uracantha*, Figure 35: 2) it is slightly shorter. On the whole, the length of the fission rib is much more variable than that of the anterior main rib. The usual range of variation for the anterior main rib is from 0.20 to 0.30 the greatest depth of the body, but this ratio may be as small as 0.13: 1 (*D. hastata*) or as large as 0.50: 1 (*D. caudata*). For the fission rib the corresponding values are 0.20 and 0.35, and 0.11: 1 (*D. hastata*) and 1.25: 1 (*D. schütti*). As a rule, the posterior main rib is the longest of these three ribs; indeed, in exceptional cases (*D. uracantha*, Figure 35: 2) it may be as much as five times longer than the fission rib. Its usual range of variation is from 0.30 to 0.60 the greatest depth of the body; but sometimes (*D. schütti*) this ratio is as large as 1.33: 1, or the rib is more or less reduced in length (*D. okamurai*, Figure 31: 5) or even absent (*D. similis*, Figure 31: 1, 2). In most species the length of this list is between 0.50 and 0.70, and the distance from its anterior to its posterior main rib between 0.40 and 0.60 the length of the hypotheca. Sometimes, however, these ratios are only 0.41: 1 and 0.33: 1 (*D. caudata*, Jörgensen, 1923, fig. 30; see also *D. sacculus*, Stein, 1883, pl. 20, fig. 11) or as much as 0.84: 1 and 0.68: 1 (*D. schütti*, Figure 40). Usually this list is subtrapeziform, wider posteriorly than anteriorly, with a pronounced postero-ventral angle, and with the ventral and posterior margins straight, or gently convex, concave, or sigmoid. From this fundamental and presumably primitive type a great number of variants have evolved. Most variable is the postero-ventral portion of the list. Sometimes this portion is more or less acuminate (*D. nias*, Figure 42: 1), the angle of its margin ranging from 5° to about 50°, or acuminate and recurved (*D. jörgenseni*, Figure 42: 8); sometimes it is subrectangular (*D. caudata*, Figure 44: 5, 6) or even rounded (*D. similis*, Jörgensen, 1923, fig. 29). The shape of this portion of the list depends on the length, shape, and

inclination of the posterior main rib. When this rib is well developed, the postero-ventral margin of the list is angular, and the rib ends at or near the vertex of the angle; when the rib is more or less reduced in length or absent, this margin is rounded; when the rib is long and straight or long and strongly concave posteriorly, this portion of the list is acuminate or acuminate and recurved, respectively. The ventral margin of the list, *i.e.*, the free margin between the anterior and posterior main ribs, is also very variable, and its shape depends largely on the relative length of the fission rib. When this rib is of moderate length, this margin is almost straight, or gently convex, concave, or sigmoid. When the rib is long, the margin is straight or gently convex, concave, or sigmoid between the anterior main rib and the fission rib, angular at the fission rib, and more or less strikingly concave between the fission rib and the posterior main rib; as a rule, the last-mentioned concavity is most pronounced just behind the fission rib (*D. swezyi*, Figure 39). The posterior margin of the list, *i. e.*, the free margin behind the posterior main rib, as previously mentioned, usually is almost straight, or gently concave, convex, or sigmoid, but it may be strongly concave (*D. acuta*, Jörgensen, 1923, fig. 20), convex (*D. caudata*, Figure 44: 4), or sigmoid (*D. jörgenseni*, Figure 42: 8); and sometimes (*D. swezyi*) it forms a more or less narrowly rounded or even acute accessory lobe, the height of which is 0.25–0.11 the greatest depth of the body. The last condition is, in a sense, an initial step in the development of a parasagittal list (see *D. trapezium*, Figure 38: 2, 3). The free margin of this list usually extends to the tip of the fission rib and of the posterior main rib, but in one species (*D. schütti*, Figure 40) it frequently terminates at some distance from these tips, leaving the distal portions of the ribs free; the length of the free portions may even slightly exceed half the length of the ribs. Sometimes (*D. recurva*, Pavillard, 1916, pl. 3, fig. 6) the ventral margin of the list is recurved to the right (see also Bergh, 1881b, p. 220). The anterior main rib always is unbranched, of moderate strength, and tapering distally; and, as a rule, it is straight or but slightly curved. The fission rib, which (always?) is double, *i.e.*, made up of two members, one on either side of the suture (*D. jörgenseni*, Plate 5, fig. 3, 7), frequently is straight or almost so, and tapers distally; sometimes, however, this rib is gently sigmoid (*D. jörgenseni*, Plate 5, fig. 7) or gently concave posteriorly (*D. swezyi*, Plate 5, fig. 9); and it may be more or less club-shaped distally (*D. schütti*, Figure 40: 1). The posterior main rib, which usually is more or less concave posteriorly but may be straight or almost so, is club-shaped distally more frequently than is the fission rib; furthermore, while the fission rib in most species is subparallel to the transverse furrow,

the posterior main rib generally is characterized by a posterior inclination of between 20° and 55°; only in exceptional cases (*D. caudata*, Figure 44) this list and the transverse furrow are subparallel. In some species this list appears to lack structural differentiation except for the main ribs; in others it may have a number of short, secondary ribs (*D. swezyi*, Plate 5, fig. 9), or a more or less developed reticulation (*D. collaris*, Plate 5, fig. 2; *D. caudata*, Stein, 1883, pl. 21, fig. 1, 2). It also should be mentioned that in *D. swezyi* (Plate 5, fig. 9) the accessory posterior lobe has a rib extending to the margin of the lobe.

Some of the primitive, as well as some of the highly differentiated species have no lists except the cingular and sulcal lists. Others have *accessory, "parasagittal"* lists (*par. l.*, Figure 29) along the sagittal suture. On the whole, these structures are less developed in Dinophysis than in Phalacroma (see p. 43). For instance, the epitheca always lacks parasagittal lists in Dinophysis, and *D. collaris* is the only known species of its genus in which the left valve has a parasagittal list; furthermore, in all but a few species, *e.g.*, *D. alata*, *D. monacantha*, these structures are limited to the posterior portion of the body. Usually the right parasagittal list is represented only by a subtriangular or wedge-shaped posterior sail, which is situated either on the midline or displaced somewhat dorsally (*D. uracantha*, Figure 35) or ventrally (*D. hastata*). Sometimes (*D. uracantha*, Figure 35:2) this sail is directed posteriorly, sometimes it is somewhat deflected dorsally (*D. schütti*, Figure 40) or ventrally (*D. hastata*, Figure 32). When fully developed, its length usually is about 0.35–0.85 the greatest depth of the body, but it may be decidedly shorter (*D. hastata*, Figure 32:13) or in exceptional cases (*D. schütti*, Figure 40:1) as long as about 1.35 the greatest depth of the body. The ratio between its length and its basal width ranges from 1.0:1 to 4.0:1 and the angle at its tip from 10° to 50°. In nearly all species this sail is distinctly separated from the left sulcal list, and only seldom (*D. hastata*, Figure 32:8) specimens are found in which these structures are so close that a connection may exist. In some species two posterior sails are developed. When this is the case, these sails either are free, *i.e.*, connected neither with each other nor with the left sulcal list (*D. nias*, Figure 42:1); or the dorsal posterior sail is free and the ventral connected with the left sulcal list (*D. triacantha*, Figure 42:2); or again, the sails are connected with each other but not with the left sulcal list (*D. jörgenseni*, Figure 42:7); or, once more, they may be connected with each other as well as with the left sulcal list (*D. jörgenseni*, Plate 5, fig. 7). The lists connecting the posterior sails with each other and with the left sulcal list sometimes are very narrow, barely distinguishable, and sometimes (*D. jörgenseni*, Plate 5, fig. 7) their mini-

mum width is not less than 0.18 the greatest depth of the body. The posterior sail may lack structural differentiation (*D. hastata*, Figure 32:14), but usually it is supported by a central rib, by marginal ribs, by both central and marginal ribs, or by a reticulum of ribs (*D. hastata*, Figure 32:1, 12, 11; *D. collaris*, Plate 5, fig. 2). The central rib may be simple, split lengthwise (*D. swezyi*, Plate 5, fig. 9), bifurcate or trifurcate proximally (*D. schütti*, Figure 40:1, 2, 3), or it is more or less broken up in a reticulum (*D. hastata*, Figure 32:3, 5, 7); furthermore, sometimes it tapers distally, and sometimes (*D. schütti*, Figure 40:1) it is club-shaped distally. As mentioned previously, the right parasagittal list very seldom extends along the dorsal side of the hypotheca. When the dorsal portion of this list is developed, it usually is of subuniform width throughout, about half as wide as the transverse furrow or less, and without structural differentiation or with a number of cross-ribs. In *D. alata* (Jörgensen, 1923, fig. 45), however, it is large, crescent-shaped, and its greatest width is not less than 0.19 the greatest depth of the body. Sometimes (*D. collaris*, Plate 5, fig. 2) the dorsal portion of the right parasagittal list is connected with the posterior sail, sometimes (*D. alata*) it is not. The left parasagittal list, which is developed in *D. collaris* only, is of subuniform width throughout and very narrow, about half as wide as the transverse furrow or less. It should be mentioned that the parasagittal lists along the dorsal side of the hypotheca appear to remain undeveloped during a comparatively long period following binary fission.

The *flagellar pore* (*f. p.*, Figure 29) is a fairly large opening, located in the longitudinal furrow, *i.e.*, on the right valve, and usually just behind or about a girdle-width behind the posterior cingular list. In *Dinophysis miles* (Weber-van Bosse, 1901, pl. 17, fig. 4) it is somewhat farther displaced posteriorly. Its shape, as a rule, is subcircular or slightly elongated, and its greatest diameter does not exceed the width of the transverse furrow. In no species of Dinophysis have pores been recorded which correspond to those found, for instance, in *Phalacroma pulchrum* and *P. giganteum* (Plate 3, fig. 1, 2) on the ventral side of the left valve, near the sagittal suture, and just in front of the anterior cingular list. It is not impossible, however, that such pores do exist in Dinophysis.

Both *flagella* arise in the flagellar pore and are well developed. The transverse flagellum (Schütt, 1895, pl. 1, fig. 5:1 and 6:1, 2) lies in the girdle and encircles the body from the left around to the right. The longitudinal flagellum (Schütt, 1895, pl. 1, fig. 5:1; 6:1, 2; 7:1), which is about as long as the body or somewhat shorter, passes posteriorly between the sulcal lists.

The structure of the *thecal wall* is less variable than in Phalacroma. In most

species there is a fairly great number of pores and poroids (Schütt, 1895, p. 21, 22) more or less uniformly scattered all over the theca; in others such structures have not been observed. Sometimes the theca appears to lack structural differentiation except for the pores and poroids, but usually it is characterized either by areolation or by reticulation. The areoles (Pavillard, 1916, pl. 3) are small, rounded, and more or less closely set pits, resembling the poroids, with which they are connected by transitional structures (Schütt, 1895, p. 22). The meshes of the reticulation always are rather small or of moderate size; in *Dinophysis jörgenseni* and *D. swezyi* (Plate 5, fig. 7, 9), which are characterized by larger meshes than most of the other species of this genus, about twelve to twenty meshes border the posterior margin of the transverse furrow. The ridges between the areoles and meshes sometimes are so fine that the structure hardly can be distinguished, sometimes (*D. alata*, Jörgensen, 1923, p. 33, fig. 45) they are rather heavy. In most species the areolation or reticulation covers the whole thecal surface, in others (*D. jörgenseni*, Plate 5, fig. 7) the regions nearest to the sagittal suture remain more or less undifferentiated. It should be remembered that the new valve of a recently divided specimen is thin and almost without structure, while in old specimens the thecal wall is relatively heavy and its structural peculiarities are well developed. In a few species (Stein, 1883, pl. 20, fig. 10, 14; pl. 21, fig. 1) small, wart-like structures are to be found at the posterior end of the theca.

With regard to the shape and structure of the *intercalary* zones of the megacytic specimens and of the ridge of adherence in *Dinophysis caudata*, *D. tripos*, and *D. miles*, see p. 51, 218.

The *protoplasmic contents* are coarsely granular, and hyaline or of a pale yellowish green or brownish color. The *nucleus*, which usually is located in the dorsal, posterodorsal, or posterior portion of the body (Schütt, 1895, pl. 1, fig. 4:3; 7:1; 6:2), is rather large, ellipsoidal, ovoidal, or spheroidal, and has moniliform chromatin reticulum. Probably in all species there are one or two large *pusules*, which open by more or less slender canals into the flagellar pore (Schütt, 1895, pl. 1, fig. 4:2). When *chromatophores* are present, they usually are rod-shaped or granular, and yellow, brown, or reddish brown in color (Schütt, 1895, pl. 1, fig. 4:1, 2; 6:2). In some forms the chromatophores are arranged in groups, named *chromatospheres* by Schütt (1895, p. 65). *Metaplasmic inclusions* of various kinds, *e.g.*, globules of fats and oils, also have been found (see Schütt (1895) and Bütschli (1885)).

The *length of the body* is very variable within the species as well as within the

genus. For the genus as a whole the variation in length thus far established ranges from 28.9 μ (*Dinophysis exigua*) to 107.0 μ (*D. caudata*).

Reproduction: — Binary fission of the free-swimming individuals is the only known mode of reproduction in Dinophysis as well as in Phalacroma, and it presumably takes place in about a similar manner in both these genera; see Plate 5, fig. 3, and p. 51. Bergh (1886, p. 80–82, pl. 5, fig. 11, 12) describes and figures specimens of *Dinophysis acuta* with the sulcal lists in a state of reorganization following binary fission.

In *Dinophysis caudata* the two schizonts, for some time following binary fission, remain attached to each other by an accessory ridge along the posterior portion of the dorsal margin of the anterior part of the hypotheca. The duration of this attachment is not known. The ridge of adherence, which appears to be resorbed fairly soon after the separation of the schizonts, sometimes (Figure 44: 6) is narrow and sometimes (Figure 44: 2) rather wide; in some specimens it lacks structural differentiation, in others it has an areolation resembling that of the thecal valves. The schizonts of the closely related *D. tripos* adhere to each other by a ridge extending almost to the tip of the dorsal peduncle (Jörgensen, 1923, fig. 38, 39). *Dinophysis miles*, in which this phenomenon is further developed and which is characterized by the extreme elongation of the dorsal peduncle, has the small ridge of adherence near the tip of the dorsal peduncle. In this species as many as eight specimens have been found to form a wheel-like colony. The specimens of this colony have their dorsal peduncles directed toward the center, like the spokes of a wheel, and all of them turn their ventral sides from the center (Weber-van Bosse, 1901, pl. 17, fig. 3). Except in the three species just mentioned, this phenomenon has not been observed in Dinophysis; probably it is limited to the Caudata group. Its significance is not known, but it may be interpreted as an adaptation to flotation. It is of interest in this connection that the members of the Caudata group are the only ones in Dinophysis in which the buoyancy has been increased by a profound modification of the shape of the body.

The "chain" figured by Weber-van Bosse (1901, pl. 17, fig. 3) is interesting also because of the unequal sizes of the component specimens. It shows that the pronounced differences in the size of the body which are so characteristic a feature in many species of Dinophysis and related genera might be brought about by a comparatively small number of rapidly repeated binary fissions.

A more or less striking increase in the size of the body preceding binary fission and accompanied by the formation of intercalary bands along the sagittal margins of the two valves has been observed in Dinophysis. However, this

phenomenon appears to occur less frequently in this genus than in Phalacroma (see p. 52). It has been found only in the following of the forty-one presumably valid species: *Dinophysis acuta* (Stein, 1883), *D. hastata* (Pavillard, 1915a, 1916, and Albatross Exped.), *D. norvegica* (Meunier, 1910), *D. punctata* (Stein, 1883, pl. 20, fig. 8), *D. recurva* (Pavillard, 1916), *D. sacculus* (Pavillard, 1916), and in the specimen figured as *D. sphaerica* by Stein (1883, pl. 20, fig. 6).

Distribution: — There are more distributional data on Dinophysis than on any other genus of Dinophysoidae. This is largely due to the fact that several species are relatively frequent in the northern European waters, which have seen submitted to very extensive and oft-repeated investigations. Unfortunately, the great majority of these data lack descriptions and figures by means of which the determinations of species may be checked (see p. 224). For this and other reasons, *e.g.*, the looseness of the concept of species held by several of the investigators, the general distribution of many of the species must be regarded as rather uncertain. On the other hand, the distribution of the genus as a whole is probably fairly well established.

Dinophysis is marine, almost exclusively eupelagic, occurs in all seas, but most of its species are restricted to waters of tropical, subtropical, and warm-temperate nature or origin. As examples of species occurring in the cold waters of the far north, *D. acuminata, D. acuta, D. arctica, D. cuneiformis, D. granulata, D. norvegica, D. semen, D. sphaerica, D. ventricosa,* and *D. vertex* may be mentioned. These species have been found either on the west coast of Norway or in the Arctic Ocean. Most of them probably are endogenetic (see Aurivillius, 1898a) in these waters; some are eurythermal and more or less widely distributed; some appear to be stenothermal, cold-water forms. It also may be mentioned that Aurivillius (1899, p. 32, 33) found representatives of this genus as far to the north as lat. 80° 31′ N. One of the species recorded by Aurivillius (1899) from lat. 80° 31′ N., viz., *D. sphaerica,* was taken by the Valdivia Expedition (Karsten, 1905) in the Antarctic Ocean as far to the south as lat. 63° 32′ S. All the species of Phalacroma found as yet in the cold waters of the far north and the far south are small, rotund, and simply organized. The species of Dinophysis in the colder waters, are also, typically, of the simpler, less highly specialized types, but some of the more or less luxuriant representatives of this genus, *e.g., D. hastata* and *D. schütti,* are occasionally carried by currents from the warm regions into the cold (Ostenfeld, 1900). Only a few species are known to be endogenetic in brackish waters, viz., *D. acuta, D. baltica,* and *D. granulata,* which have been found in the less saline regions of the Baltic Sea. Other species have been recorded from the

brackish regions of the Baltic, but since their specific determinations are very uncertain the list is restricted to the three species just mentioned (see Jörgensen, 1912, p. 10, 11). It may be added that Oye (1921) found *D. acuta* to be the only species of this genus occurring in the brackish waters at Batavia (Java).

The genus is found in surface waters, but the optimum habitat of most of its species appears to be the deeper levels of photosynthesis. However, the vertical distribution of the genus is very incompletely known, since but few records based on catches made with closing nets are available. The following records from Karsten's (1905, 1906, 1907) reports on the phytoplankton of the VALDIVIA Expedition are the only ones published at the present writing. *Dinophysis ovum* was found in catches from 35–15 m. and 55–35 m. at Station 145; *D. hastata* and *D. uracantha* in a haul from 80–60 m. at Station 169; *D. caudata*, in a catch from 200–100 m. at Station 67. *Dinophysis sphaerica* was taken at the following stations: — Station 151, 100–10 m. and 300–200 m.; Station 152, 80–60 m.; Station 169, 60–40 m. All the species recorded were reported as "living."

Many of the species appear to be more or less rare, but some of them, *e.g.*, *D. miles*, *D. acuta*, and *D. caudata*, have been taken in rather large numbers; see Schröder (1906a, p. 333), who recorded *D. miles* as very common ("cc"), Lohmann (1908a, p. 148), and Jörgensen (1923, p. 27). It should be remembered in this connection that Hensen (1911, p. 164) has found this genus to pass "wohl recht leicht durch die Netzmaschen."

Representatives of Dinophysis were found at eighty-nine (70.0%) out of the 127 stations of the Expedition from which dinoflagellates were recorded. These eighty-nine stations are distributed over the whole area covered by the Expedition in the following manner (Plate 25): —

	Number of Stations and Occurrences	Number and % of Occurrences		
				%
California Current	4571, 4574, 4580, 4583	4	4	100
Mexican Current	4587, 4588, 4590, 4592, 4594, 4596, 4598, 4600, 4604, 4605, 4545, 4546	13	12	92.3
Panamic Area	4609, 4611, 4613, 4615, 4617, 4619, 4631, 4634, 4637, 4638, 4639, 4640, 4644	17	13	76.5
Peruvian Current	4647, 4648, 4649, 4650, 4651, 4652, 4655, 4657, 4659, 4660, 4663, 4664, 4665, 4667, 4668, 4669, 4670, 4671, 4673, 4675, 4676, 4678	27	22	85.2
Easter Island Eddy	4689, 4691, 4695, 4697, 4699	10	5	50
Galapagos Eddy	4713, 4715, 4716	4	3	75
South Equatorial Drift	4679, 4680, 4681, 4683, 4687, 4701, 4705, 4707, 4709, 4711, 4717, 4719, 4720, 4721, 4722, 4724, 4727, 4728, 4730, 4732, 4734, 4736, 4737, 4739, 4740, 4741	45	26	57.8
South Equatorial Current	4742	3	1	33.3
Equatorial Counter Current	4542	2	1	50
North Equatorial Current	4544	2	1	50

At sixty-four of these eighty-nine stations Dinophysis was taken in vertical hauls and at thirty-six stations in surface hauls. Most of the records from vertical hauls are from 300–0 fathoms, some are from 800, 400, 150, 100–0 fathoms. Vertical hauls were made at sixty-eight of the 127 stations. The genus thus was found at not less than 94.2% of the stations at which vertical hauls were made.

Disregarding the stations at which only surface catches were made, the record stations are distributed over the area covered by the Expedition in the following manner:—

	Number of Stations	Number and % of Occurrences	
			%
California Current	4	4	100
Mexican Current	5	5	100
Panamic Area	6	6	100
Peruvian Current	22	19	86.4
Easter Island Eddy	5	5	100
Galapagos Eddy	2	2	100
South Equatorial Drift	23	22	95.6
South Equatorial Current	1	1	100

There were no vertical hauls made in the Equatorial Counter Current or in the North Equatorial Current.

Surface catches and Salpa stomachs of specimens taken in surface waters (eighty-one surface catches and twenty-four samples of Salpa stomachs) were examined from eighty-two stations. The genus, as previously mentioned, was taken in surface hauls at thirty-six stations, *i.e.*, at 43.9% of all the surface stations. Taking into consideration the surface stations only, these thirty-six record stations are distributed in the following manner:—

	Numbers of Stations and Occurrences	No. of Stations	Number and % of Occurrences	
				%
California Current	4571, 4574, 4580, 4583	4	4	100
Mexican Current	4588, 4592, 4596, 4600, 4604, 4545, 4546	9	7	77.8
Panamic Area	4611, 4615, 4619, 4631, 4638, 4639, 4640, 4644	13	8	61.5
Peruvian Current	4649, 4650, 4657, 4659, 4660, 4666, 4669, 4676, 4678	20	9	45
Easter Island Eddy	0000	5	0	0
Galapagos Eddy	4716	2	1	50
South Equatorial Drift	4680, 4709, 4720, 4727	23	5	21.7
South Equatorial Current	0000	2	0	0
Equatorial Counter Current	4542	2	1	50
North Equatorial Current	4544	2	1	50

On account of the prevalence of Dinophysis in deeper waters, the table showing the distribution and the frequency of the record stations at which *vertical* hauls were made should be used as an indicator of the horizontal distribution of this genus in the area investigated by the Expedition. This table shows that the

genus is almost evenly distributed throughout this area. In the region with the lowest percentage of record stations, *viz.*, the Peruvian Current, it was taken at not less than 86.4% of the stations with vertical hauls; and in the California Current, Mexican Current, Panamic Area, Easter Island Eddy, Galapagos Eddy, and South Equatorial Current it occurred at all the stations with vertical hauls. The even distribution of this genus is evident not only from the distribution and frequency of the record stations but also from the distribution and frequency of the records of species (Plate 25). Of the five most frequent species, *D. hastata*, *D. jörgenseni*, *D. schütti*, and *D. uracantha* (Figure 34, 43, 41, 36) were found to be more or less evenly distributed throughout the area investigated; *D. caudata*, on the other hand, was found to have a rather peculiar distribution; almost all its record stations are located in the coastal currents (Figure 45).

The surface record stations of Dinophysis are very unevenly distributed. While this genus was found at not less than twenty-eight (60.9%) out of the forty-six surface stations in the California Current, Mexican Current, Panamic Area, and Peruvian Current, it did not occur at more than six (20.0%) out of the thirty surface stations in the South Equatorial Drift, the Easter Island Eddy, and the Galapagos Eddy. However, this is due to the fact that not less than twenty-eight (63.7%) out of the forty-four surface records are of *D. caudata*, a species occurring almost exclusively in the coastal currents. If this species is disregarded, the genus occurred at seven (15.2%) out of the forty-six surface stations in the coastal regions and at six (20.0%) out of the thirty surface stations in the South Equatorial Drift, the Easter Island Eddy, and the Galapagos Eddy.

There are 170 records of species of Dinophysis from vertical catches. Out of these 170 records 1 (0.6%; Station 4659) showed a frequency of 12%; 1 (0.6%; Station 4571) 9%; 1 (0.6%; Station 4650) 3%; 11 (6.5%; Stations 4574, 4598, 4609, 4638, 4651, 4655, 4671, 4675, 4676, 4689, 4695) 2%; 34 (20.0%; Stations 4571, 4580, 4587, 4590, 4613 [2 records], 4617, 4634, 4637, 4638 [2 records], 4647, 4648, 4657, 4663 [2 records], 4667, 4670, 4671, 4679, 4681 [2 records], 4689, 4699, 4701, 4715 [2 records], 4722, 4724, 4734, 4737, 4740 [2 records], 4742) 1%; 122 (71.8%) showed a frequency of less than 1%.

There are forty-four records of species from surface catches. Out of these forty-four records 1 (2.3%; Station 4571) showed a frequency of 72%; 1 (2.3%; Station 4611) 29%; 1 (2.3%; Station 4649) 11%; 1 (2.3%; Station 4669) 10%; 1 (2.3%; Station 4639) 9%; 1 (2.3%; Station 4615) 6%; 1 (2.3%; Station 4640) 5%; 1 (2.3%; Station 4720) 4%; 3 (6.8%; Stations 4657, 4659, 4676) 3%; 3 (6.8%; Stations 4644, 4650, 4544) 2%; 8 (18.2%; Stations 4574, 4588, 4592, 4619, 4666

[2 records], 4716, 4542) 1%; 22 (50.0%) showed a frequency of less than 1% or did not have the frequency established. Of these records all but one (*Dinophysis sphaerica*, 4%, Station 4720) showing a frequency of 2% or more refer to *D. caudata*.

As will be seen from a comparison between the last two paragraphs and the corresponding paragraphs in the section on the distribution of the genus Phalacroma, the number of records of species as well as the average frequency of the individual species is less in Dinophysis than in Phalacroma. Only one species of Dinophysis, viz., *D. caudata*, was found to be relatively frequent in the material of the Expedition.

Coincident occurrence of different species of Dinophysis in catches from 300 (800, 400, 150, 100)–0 fathoms is recorded at the following of the sixty-four stations mentioned above: — six species occurred coincidently at five stations (7.8%; Stations 4679, 4691, 4701, 4711, 4730); five species at three stations (4.7%; Stations 4638, 4681, 4732); four species at seven stations (10.9%; Stations 4637, 4659, 4676, 4697, 4705, 4713, 4722); three species at ten stations (15.6%; Stations 4605, 4613, 4650, 4651, 4652, 4671, 4699, 4715, 4717, 4740); two species at twenty-eight stations (43.8%; Stations 4571, 4574, 4580, 4583, 4587, 4590, 4594, 4598, 4609, 4634, 4647, 4655, 4663, 4665, 4667, 4673, 4675, 4683, 4687, 4689, 4695, 4709, 4721, 4724, 4734, 4737, 4739, 4742).

Coincident occurrence of different species of this genus in surface catches is recorded at the following of the thirty-six surface stations mentioned above: — three species occurred coincidently at two stations (5.5%; Stations 4588, 4676); two species at four stations (11.1%; Stations 4583, 4596, 4666, 4545).

At the thirty-six surface stations just mentioned, there are records of only seven of the twenty species of this genus found in the material of the Expedition. The number of surface records of each of these seven species is as follows: — *Dinophysis caudata*, twenty-eight records, one of which is from a Salpa stomach; *D. hastata*, eight records; *D. exigua*, two records, one of which is from a Salpa stomach; *D. sphaerica*, two records, one of which is from a Salpa stomach; *D. uracantha*, two records, one of which is from a Salpa stomach; *D. jörgenseni*, one record; *D. schütti*, one record. Thus not less than thirty-six (81.8%) out of the forty-four surface records refer to two species only, one of which, *D. caudata*, seems to be predominantly a surface species.

The fact that Dinophysis was found to be somewhat evenly distributed throughout the area investigated by the Expedition leads to the inference that it is fairly evenly distributed throughout all the tropical and subtropical seas.

It may also be mentioned that only seven out of the forty-one presumably valid species of this genus have been found only in the material of the Expedition.

Historical Discussion and Systematics

Dinophysis was the first genus of the tribe Dinophysoidae to be established. It was founded for two new species, *D. acuta* and "*D. michaelis*" (= *D. limbata*), by Ehrenberg (1840a, p. 124), who gave it but a short and superficial diagnosis. Diagnoses of this genus have also been published by Griffith and Henfrey (1856, p. 211; 1875, p. 253; 1883, p. 264), Diesing (1866, p. 98), Fromentel (1874, p. 196), Kent (1881, p. 458), Bergh (1881a, p. 5; 1881b, p. 226), Bütschli (1885, p. 1010), Delage and Hérouard (1896, p. 385), Schütt (1896, p. 27), Paulsen (1908, p. 12), Meunier (1919, p. 79), Jörgensen (1923, p. 18), and Lebour (1925, p. 79). Most of these generic diagnoses are partial and inadequate; the one by Paulsen (1908) is the best. A short discussion of this genus was given by Claparède and Lachmann (1858, p. 406). Fairly lengthy descriptions and discussions were published by Bergh (1881b, p. 218) and by Gourret (1883, p. 74); Bergh's (1881b) account is comparatively good, while the one by Gourret (1883) is characterized by numerous imperfect observations and misinterpretations.

Besides the two specific names of Dinophysis established by Ehrenberg (1840a), the following specific and subspecific names of this genus are to be found in the literature:—

D. atlantica Ehrenberg (1854)
D. norvegica Claparède & Lachmann (1858)
D. ventricosa Claparède & Lachmann (1858)
D. acuminata Claparède & Lachmann (1858)
D. rotundata Claparède & Lachmann (1858)
D. ovata Claparède & Lachmann (1858)
D. laevis Claparède & Lachmann (1858)
D. norvegiana Claparède & Lachmann, Moss (1877)
D. arctica Mereschowsky (1878)
D. caudata Kent (1881)
D. acuta Ehrenberg var. *geminata* Pouchet (1883)
D. galea Pouchet (1883)
D. hastata Stein (1883)
D. sphaerica Stein (1883)
D. sacculus Stein (1883)
D. uracantha Stein (1883)
D. homunculus Stein (1883)
D. jourdani Gourret (1883)
D. allieri Gourret (1883)
D. inaequalis Gourret (1883)
D. tripos Gourret (1883)
D. acuacuta Bergh, Balbiani (1884b)
D. semicarinata Grenfell (1887)
D. armata Daday (1888)
D. laevis Stein, Daday (1888)
D. lenticula Bergh, Daday (1888)
D. vermiculata Pouchet (1894)
D. ovum Schütt (1895)
D. ocuta Hjort & Gran (1899)
D. ovalis Claparède & Lachmann, Ostenfeld (1899)
D. vanhöffeni Ostenfeld (1899)
D. granulata Cleve (1899c)
D. rudgei Murray & Whitting (1899)
D. schütti Murray & Whitting (1899)
D. rotundata Claparède & Lachmann var. *laevis* (Claparède & Lachmann) Jörgensen (1899)
D. homunculus Stein var. *allieri* (Gourret) Lemmermann (1899a)
D. homunculus Stein var. *incurva* Lemmermann (1899a)
D. homunculus Stein var. *tripos* (Gourret) Lemmermann (1899a)
D. miles Cleve (1900b)
D. truncata Cleve (1900f)
D. schröteri (Forti, 1901), described as *Heteroceras schröteri*
D. aggregata Weber-van Bosse (1901)

D. acuminata Claparède and Lachmann var. *granulata* (Cleve) Jörgensen (1901)
D. miles Cleve var. *aggregata* (Weber-van Bosse) Lemmermann (1901a)
D. miles Cleve f. *maris rubri* Ostenfeld & Schmidt (1901)
D. miles Cleve f. *indica* Ostenfeld & Schmidt (1901)
D. homunculus Stein var. *pedunculata* Schmidt (1901)
D. intermedia Cleve (1902b)
D. sphaeriaca Entz (1902b)
D. acuta Ehrbg. var. *steini* Lemmermann (1902a)
D. acuminata Claparède and Lachmann f. *reniformis* Pavillard (1905)
D. miles Cleve f. *maris jonii* Schröder (1906a)
D. pavillardi Schröder (1906a)
D. homunculus Stein var. *appendiculata* Zacharias (1906)
D. homunculus Stein var. *carinata* Zacharias (1906)
D. triacantha Kofoid (1907a)
D. ellipsoides Kofoid (1907b)
D. diegensis Kofoid (1907b)
D. diegensis f. *curvata* Kofoid (1907b)
D. nias Karsten (1907)
D. norvegica Claparède & Lachmann f. *crassior* Paulsen (1907)
D. norvegica Claparède & Lachmann f. *debilior* Paulsen (1907)
D. ovum Schütt var. *baltica* Paulsen (1908)
D. schröderi Pavillard (1909)
D. cuneiformis Meunier (1910)
D. vertex Meunier (1910)
D. semen Meunier (1910)
D. apiculata Meunier (1910)
D. homunculus Stein var. *gracilis* Schröder (1911)
D. collaris Kofoid & Michener (1911)
D. expulsa Kofoid & Michener (1911)
D. rugosa Kofoid & Michener (1911)
D. bihastata Hensen (1911)
D. bipes Hensen (1911)
D. hormunculus Hensen (1911)
D. hornunculus Hensen (1911)
D. pluripes Hensen (1911)
D. porosa Hensen (1911)
D. sphaeroidea Hensen (1911)
D. tripes Hensen (1911)
D. geminata (Pouchet) Kofoid & Ridgen (1912a)
D. norvegica Claparède & Lachmann var. *crassicornis* Smyth (1912)
D. dens Pavillard (1915b)
D. miles Cleve f. *schröteri* (Forti) Ostenfeld (1915)
D. pedunculata (Schmidt) Ostenfeld (1915)
D. homunculus Stein var. *ventricosa* Pavillard (1916)
D. diegensis Kofoid var. *caudata* Pavillard (1916)
D. intermedia Pavillard (1916)
D. lenticula Pavillard (1916)
D. acuta Ehrenberg var. *sculpta* Jörgensen (1923)
D. alata Jörgensen (1923)
D. caudata Kent var. *abbreviata* Jörgensen (1923)
D. caudata Kent var. *allieri* (Gourret) f. *speciosa* Jörgensen (1923)
D. caudata Kent f. *marmarae* Jörgensen (1923)
D. caudata Kent f. *pontica* Jörgensen (1923)
D. caudata Kent f. *subdiegensis* Jörgensen (1923)
D. hastata Stein var. *phalacromides* Jörgensen (1923)
D. hastata Stein var. *uracanthides* Jörgensen (1923)
D. intermedia Pavillard f. *pachyderma* Jörgensen (1923)
D. kofoidi Jörgensen (1923)
D. punctata Jörgensen (1923)
D. pusilla Jörgensen (1923)
D. tripos Gourret f. *brevicauda* Jörgensen (1923)
D. uracantha Stein var. *mediterranea* Jörgensen (1923)
D. fortii Pavillard (1923a)
D. hastata Stein var. *parvula* Lindemann (1923)
D. homunculus Stein var. *latus* Lindemann (1923)
D. rotundata Claparède & Lachmann var. *intermedia* Lindemann (1923)
D. schütti Murray & Whitting var. *uracanthoides* Forti & Issel (1924)

In the present paper the following new names have been introduced:—*D. baltica, D. caudata, D. acutiformis, D. exigua, D. jörgenseni, D. monacantha, D. okamurai, D. recurva, D. reniformis, D. similis, D. swezyi, D. trapezium,* and *D. urceolus.*

Among the species enumerated above, *Dinophysis rotundata* Claparède and Lachmann (1858), *D. laevis* Claparède and Lachmann (1858) (*D. rotundata* var. *laevis* of Jörgensen (1899)), *D. ovata* Claparède and Lachmann (1858), and *D. expulsa* Kofoid and Michener (1911) have been transferred to Phalacroma (see p. 59). On the other hand, *Dinophysis rotundata* Claparède and Lachmann

var. *intermedia* Lindemann (1923) apparently belongs to Dinophysis; its specific allocation is uncertain, and the subspecific name, though preoccupied, is retained temporarily until the systematic status of this form is determined. *Dinophysis jourdani* Gourret (1883) and *D. armata* Daday (1888) are identical and belong to Ceratocorys, according to Kofoid (1910a) and Jörgensen (1911). *Dinophysis galea* Pouchet (1883) includes four different species, none of which belongs to Dinophysis. *Dinophysis intermedia* Cleve (1902b) should be transferred to Histioneis. *Dinophysis rugosa* Kofoid and Michener (1911) is the type of Histiophysis.

Dinophysis bihastata, D. bipes, D. pluripes, D. porosa, D. sphaeroidea, and *D. tripes,* all of Hensen (1911), are *nomina nuda,* and there is no information published as yet as to their organization. *Dinophysis ocuta* Hjort and Gran (1899) and *D. norvegica* Claparède and Lachmann var. *crassicornis* Smyth (1912), which also are *nomina nuda,* evidently are due to slips of the pen and are intended for *D. acuta* Ehrenberg and *D. norvegica* Claparède and Lachmann var. *crassior* Paulsen, respectively; see Ostenfeld (1916b, p. 13). *D. norvegiana* Claparède and Lachmann, Moss (1877), *D. acuacuta* Bergh, Balbiani (1884b), *D. laevis* Stein, Daday (1888), *D. lenticula* Bergh, Daday (1888), *D. sphaeriaca* Entz (1902b), and *D. hormunculus* and *D. hornunculus* Hensen (1911) also are due to slips of the pen and stand for *Dinophysis norvegica* Claparède and Lachmann, *D. acuta* Ehrenberg, *Dinopyxis laevis* Stein, *Diplopsalis lenticula* Bergh, *Dinophysis sphaerica* Stein, and *Dinophysis homunculus* Stein, respectively. The name *Dinophysis ovalis* Claparède and Lachmann, Ostenfeld (1899) is due to an error and should be *D. ovata* Claparède and Lachmann.

A fairly great number of the names mentioned in the first two paragraphs of this section are synonyms. The reasons why *D. caudata* has so many synonyms are that Kent's (1881) original description was not accompanied by any figures and was disregarded until recently; that three investigators, Pouchet (1883), Stein (1883), and Gourret (1883), described and named this species almost simultaneously but independently of each other; and that this species is characterized by an exceptionally great variability (see p. 314).

Dinophysis tripos Gourret (1883), which some investigators refer to *D. caudata* but which is considered as a distinct species, has the following synonyms: *D. tripos* f. *brevicauda* Jörgensen (1923), *D. homunculus* var. *appendiculata* Zacharias (1906), *D. homunculus* var. *incurva* Lemmermann (1899a), and *D. homunculus* var. *tripos* (Gourret) Lemmermann (1899a).

Dinophysis diegensis Kofoid (1907b), of which there are two varieties, var.

curvata Kofoid (1907b) and var. *caudata* Pavillard (1916), *D. caudata* Kent f. *subdiegensis* Jörgensen (1923), and *D. caudata* f. *acutiformis* nobis have a rather uncertain systematic status. Indeed, it is not impossible that all these forms are established on specimens of *D. caudata* degenerated in coastal waters, but this cannot be proven. *Dinophysis kofoidi* Jörgensen (1923) is a synonym of *D. subdiegensis*, while *D. caudata* f. *acutiformis* is a new name applied to the form previously established by Pavillard (1916) under the name *D. homunculus* var. *ventricosa*. Pavillard's name *ventricosa* had to be discarded since it was antedated by *D. ventricosa* Claparède and Lachmann (1858). If Pavillard's (1916) variety *caudata* is a distinct systematic unit, then, of course, its name must be changed.

Dinophysis miles Cleve (1900b), which is a close relative of *D. caudata* and *D. tripos*, comprises two rather different varieties, viz., *D. miles miles* (Cleve, 1900b, fig. 1a) and *D. miles* f. *schröteri* (Forti) Ostenfeld (1915). These two forms probably are specifically distinct, but this question cannot be settled as yet. *Dinophysis miles miles* is identical with *D. miles* f. *maris rubri* Ostenfeld and Schmidt (1901). *Heteroceras schröteri* Forti (1901), *Dinophysis aggregata* Weber-van Bosse (1901), *D. miles* f. *indica* Ostenfeld (1901), and *D. miles* var. *aggregata* (Weber-van Bosse) Lemmermann (1901a) are synonyms of *D. miles* f. *schröteri*. Another variety of *D. miles*, established by Schröder (1906a) under the name of *D. miles* f. *maris jonii*, has not been figured or sufficiently described as yet, and thus must be classified as uncertain.

Dinophysis acuta Ehrenberg (1840a) and *D. norvegica* Claparède and Lachmann (1858), which are very similar but nevertheless undoubtedly specifically distinct, have been badly confused. *Dinophysis acuta*, the type of the genus, was described from the Bay of Kiel, but the form to which its name has been applied in most of the recent papers possibly does not occur in the Baltic (Ostenfeld, 1913a, p. 307), or if it does occur there, it is allogenetic, appearing as a rare guest only (Jörgensen, 1912, p. 11). On the other hand, the form which has been called *D. norvegica* by most authors is common and certainly endogenetic in the southwestern portion of the Baltic. Ehrenberg's (1840a) description and figure of *D. acuta* would be too poor for certainty of specific identification if both these forms were frequent in the Bay of Kiel, but the fact that only one of them occurs there constantly and in relatively great abundance and the fact that all the remaining species of Dinophysis found in the Baltic are strikingly different from *D. acuta* as figured by Ehrenberg makes it necessary to accept Ehrenberg's data and apply the name *D. acuta* to the one of the two species that is endogenetic in the Bay of Kiel (see Aurivillius, 1898a, p. 104, and Jörgensen, 1923, p. 18). In

other words, *D. acuta* Ehrenberg should be applied to the form figured as *D. acuta* by Bergh (1881b, pl. 15, fig. 49, 50) and by Lohmann (1908a, p. 201, fig. 51) and under the name of *D. norvegica* var. *debilior* by Paulsen (1907, fig. 1b). On the other hand, *D. norvegica* Claparède and Lachmann is identical with the form figured by Paulsen (1907, fig. 1a) as *D. norvegica* var. *crassior*. *Dinophysis acuta* Jörgensen (1899, pl. 1, fig. 2), which by most authors has been treated as the type of *D. acuta* Ehrenberg, almost certainly is a synonym of *D. ventricosa* Claparède and Lachmann (1858, pl. 20, fig. 20) (see Jörgensen, 1899, p. 28). Furthermore, *D. acuta* var. *steini* Lemmermann (1902a), which is founded on *D. acuta* Stein (1883, pl. 20, fig. 14–17), probably is a synonym of *D. acuta* Ehrenberg, while *D. acuta* Stein (1883, pl. 20, fig. 20) is referable to *D. ventricosa* Claparède and Lachmann. *D. acuta* var. *sculpta* Jörgensen (1923) probably is based on an old, thick-walled specimen of *D. ventricosa*.

Dinophysis hastata var. *phalacromides* Jörgensen (1923), var. *uracanthides* Jörgensen (1923), var. *parvula* Lindemann (1923), and *D. uracantha* var. *mediterranea* Jörgensen (1923) are treated as synonyms of *D. hastata* Stein (1883); it should be mentioned, however, that the scope of the last species is very uncertain, and that the present arrangement is tentative. Whether *D. schütti* var. *uracanthoides* Forti and Issel (1924) is a distinct systematic unit or a modification of *D. schütti* is uncertain. Schröder's (1906a) elevation of *D. acuminata* Claparède and Lachmann f. *reniformis* Pavillard (1905) to the rank of species seems to be justified. However, the name used by him, viz., *D. pavillardi*, should be replaced by *D. reniformis;* see also Jörgensen (1923, p. 22). Instead of *D. lenticula* Pavillard (1916), which must be discarded since it is antedated by *D. lenticula* Bergh, Daday (1888), we suggest the name *D. recurva*, nom. nov. *D. vanhöffeni* Ostenfeld (1899) and *D. apiculata* Meunier (1910) are of somewhat uncertain allocation, but most probably they are identical with *D. ovata* Claparède and Lachmann.

Dinophysis acuminata Claparède and Lachmann (1858), *D. arctica* Mereschowsky (1878), and *D. granulata* Cleve (1899c) have been badly confused, and an attempt to unravel their synonymies will meet with great difficulties. For the present all of them should be treated as specifically distinct. *Dinophysis arctica* is a valid species according to Paulsen (1911b, p. 304); and *D. granulata* is specifically distinct according to Jörgensen (1912, p. 10, 11). *Dinophysis acuminata* Claparède and Lachmann var. *granulata* (Cleve) Jörgensen (1901) thus becomes a synonym. See also (p. 230) the treatment of *D. michaelis* Ehrenberg.

Dinophysis acuminata Claparède and Lachmann was described from the west coast of Norway. The type, as figured, is characterized especially by being

much broader posteriorly than anteriorly and by having a small, triangular antapical protuberance somewhat ventrally to the midline of the body. Under this name Jörgensen (1899) gave a short description and fairly good figures of a form which he had found in hundreds of specimens on the west coast of Norway; the three specimens figured, however (1899, pl. 1, fig. 7–9), differ strikingly from the type as figured by Claparède and Lachmann (1858, pl. 20, fig. 17); they are about as wide anteriorly as posteriorly or even slightly narrower posteriorly than anteriorly, and they have some small, rounded protuberances in the middle of the postmargin of the body. In a later paper Jörgensen (1912) points out that *D. acuminata* is very variable and that there is, on the west coast of Norway, a form that agrees fairly well ("viel besser, und ziemlich genau") with the type specimen. Paulsen (1912, p. 261) considers it possible that it will prove necessary to divide *D. acuminata* into two or more species. These facts seem to indicate, first, that *D. acuminata* at the present time is a collective species and, second, that the form described and figured by Jörgensen (1899, pl. 1, fig. 7–9) is specifically distinct from the type. The last circumstance is the more confusing since many modern investigators evidently have treated Jörgensen's (1899) figures as if they had been drawn from cotypes.

Levander (1900a, p. 15, fig. 1) described and figured a form from the Gulf of Finland which he called "Dinophysis sp. (? *ovum* Schütt)." Later this form was treated by Paulsen (1908) under the name *D. ovum* Schütt var. *baltica*. The question as to whether this form is specifically distinct or only a brackish-water modification of *D. ovum* is, of course, impossible to settle at present. However, these two forms differ in so many respects that they should be considered as different species until it has been proven that they are genetically identical. The most important differences are to be found in the size of the body, in the shape of the transverse furrow and of the epitheca, and in the width and shape of the cingular and sulcal lists. The name of this species should be *Dinophysis baltica* Paulsen. It may be mentioned in this connection that *D. baltica* has been recorded only by Levander. Thus it was not found in the Finnish waters by Jörgensen (1912), who, on the other hand, recorded *D. granulata* Cleve, a species that is strikingly similar to *D. baltica* and that has never been recorded by Levander. Are *D. baltica* and *D. granulata* Jörgensen (1912) identical?

Dinophysis cuneiformis, *D. semen*, and *D. vertex* Meunier (1910), which are of somewhat uncertain systematic status, have in the present paper been treated as valid species. *Dinophysis cuneiformis* recalls *D. acuta* Ehrenberg, and *D. semen* shows a great resemblance to *D. granulata* Cleve.

Due to insufficient data, *Dinophysis michaelis* Ehrenberg (1840a) cannot be determined at the present time; it may be identical either with *D. acuminata* Jörgensen (1899) or with *D. granulata* Cleve (1899c), both of which occur in the southern portion of the Baltic (Jörgensen, 1912). However, it is not impossible that a careful examination of rich material from the type locality, the Bay of Kiel, will allow the identification of this species with a fair degree of accuracy. Judging by the information published, it appears most probable that this species is identical with *D. rotundata* Lohmann (1908a, p. 201, fig. 43) and with *D. granulata* Jörgensen (1912). With regard to the name *D. michaelis*, Ehrenberg (1840a, p. 151) writes as follows: "Der erste Beobachter dieses Thierchens ist Dr. Michaelis in Kiel, unter dessen Zeichnungen, die er mir durchsehen liess, diese Form bereits war. Ich habe deshalb diesen Specialnamen vorgezogen." The name *D. limbata* had evidently been used by Ehrenberg (1840a) in his manuscript and engraved (his Plate 4, fig. 15) before he saw Dr. Michaelis's drawings, which appear to have determined the change in the text from *limbata* to *michaelis*. However, in the above-mentioned paper the name *michaelis* precedes *limbata* and thus has priority.

Dinophysis atlantica Ehrenberg (1854) and *D. vermiculata* Pouchet (1894) also must be regarded as impossible to determine with a fair degree of certainty at the present time. The first species was considered by Jörgensen (1923) as possibly identical with *D. intermedia* [*fortii*]; the other is closely connected with *D. acuta* Ehrenberg, *D. norvegica* Claparède and Lachmann, and *D. ventricosa* Claparède and Lachmann.

At present there are forty-one presumably valid species of Dinophysis, one presumably valid subspecies, and four species and six subspecies of more or less uncertain status. The valid species and subspecies are as follows: —

D. acuminata Claparède & Lachmann (1858)
D. acuta Ehrenberg (1840a)
D. alata Jorgensen (1923)
D. arctica Mereschowsky (1878)
D. baltica Paulsen (1908) nobis
D. caudata Kent (1881)
D. collaris Kofoid & Michener (1911)
D. cuneiformis Meunier (1910)
D. dens Pavillard (1915b)
D. ellipsoides Kofoid (1907b)
D. exigua, sp. nov.
D. fortii Pavillard (1923a)
D. granulata Cleve (1899c)
D. hastata Stein (1883)
D. jörgenseni, sp. nov.
D. miles Cleve (1900b)
D. miles Cleve f. *schroteri* (Forti) Ostenfeld (1915)
D. monacantha, sp. nov.
D. nias Karsten (1907)
D. norvegica Claparède & Lachmann (1858)
D. okamurai, sp. nov.
D. ovum Schütt (1895)
D. punctata Jörgensen (1923)
D. pusilla Jörgensen (1923)
D. recurva, sp. nov.
D. reniformis Pavillard (1905)
D. rudgei Murray & Whitting (1899)
D. sacculus Stein (1883)
D. schröderi Pavillard (1909)
D. schütti Murray & Whitting (1899)
D. semen Meunier (1910)
D. similis, sp. nov.
D. sphaerica Stein (1883)
D. swezyi, sp. nov.

D. trapezium, sp. nov.
D. triacantha Kofoid (1907a)
D. tripos Gourret (1883)
D. truncata Cleve (1900f)
D. uracantha Stein (1883)
D. urceolus, sp. nov.
D. ventricosa Claparède & Lachmann (1858)
D. vertex Meunier (1910)

The species and subspecies of more or less uncertain status are as follows: —

D. atlantica Ehrenberg (1854)
D. caudata Kent f. *acutiformis*, f. nov.
D. caudata Kent var. *subdiegensis* Jörgensen (1923)
D. diegensis Kofoid (1907b)
D. diegensis Kofoid var. *caudata* Pavillard (1916)
D. diegensis var. *curvata* Kofoid (1907b)
D. michaelis Ehrenberg (1840a)
D. miles Cleve f. *maris jonii* Schröder (1906a)
D. schütti Murray & Whitting var. *uracanthoides* Forti & Issel (1924)
D. vermiculata Pouchet (1894)

Nearly all the published descriptions of species and subspecies are short and incomplete, and most of them have no or but few data of variation for consideration. The descriptions published by Kofoid (1907a) and by Kofoid and Michener (1911) are preliminary and based on the same material as those of the present paper. Thus most of the species are very incompletely known, and considerable work will be necessary for a truly scientific delimitation of these units. Especially urgent at the present time is a thorough revision of the species occurring in the waters of northern Europe. As will be seen from the account given above, most of these species were established when protozoölogy was still in its infancy; nevertheless nobody, except Jörgensen (1899), has even attempted a revision. Furthermore, the synonymies of these Nordic species will cause great difficulties, since most of the planktonologists have not been specialists in dinoflagellates and so have applied superficial and unsatisfactory criteria in their determinations of this group.

Pavillard (1916) divided Dinophysis into five sections, which he designated by the names of the representative species, viz., Homunculus, Acuta, Sacculus, Hastata, and Sphaerica. The species included in these sections are as follows: — Homunculus: — *D. homunculus*, *D. homunculus* var. *ventricosa*, *D. diegensis* var. *caudata*, and *D. tripos*. Acuta: — *D. dens*, *D. acuta*, *D. vertex*, *D. ovum*, *D. intermedia*, and *D. schröderi*. Sacculus: — *D. sacculus*, *D. pavillardi*, and *D. lenticula*. Hastata: — *D. hastata*, *D. uracantha*, and *D. schütti*. Sphaerica: — *D. sphaerica*. Jörgensen (1923) divided this genus into the following sections: — Acutae: — *D. acuta*, *D. intermedia*, *D. atlantica*, *D. schröderi*, and *D. dens*. Ovum: — *D. sacculus*, *D. reniformis*, *D. acuminata*, *D. ovum*, *D. lenticula*, and *D. punctata*. Sphaericae: — *D. sphaerica*. Homunculus: — *D. caudata*, *D. caudata* f. *ventricosa*, *D. caudata* var. *subdiegensis*, *D. diegensis* and its two varieties, and *D. tripos*. Hastatae: — *D. hastata*, *D. uracantha*, *D. pusilla*, and *D. alata*. Scolops: — *D. schütti* and *D. triacantha*. Jörgensen (1923) gave his six sections short diagnoses, while Pavillard (1916) did not attempt any characterization of his.

Claparède and Lachmann (1858), Bergh (1881b), Gourret (1883), Stein (1883), and Bütschli (1885) attempted to homologize the different structures in Dinophysoidae and Peridinioidae. Of these attempts the one by Gourret (1883) is characterized by many and peculiar misinterpretations; *e.g.*, the main ribs of the left sulcal list and the central rib of the posterior sail in Dinophysis were homologized with the horns in Ceratium; and the sulcus in Dinophysis was considered to be on the right side of the body. The first detailed description of the sulcal lists was given by Bergh (1881b), who in a later paper (1886) gave the first clear and correct account of the position of these structures relative to the thecal valves. Bergh (1881b) also studied the structure and organization of the thecal wall and of the cell-contents, but most of the knowledge in this field is due to Bütschli (1885) and Schütt (1895, 1899). A few remarks on the adaptive value of the furrows and lists in Dinophysis were made by Francé (1923). With regard to the interpretation of the megacytic specimens, see page 62. Pouchet (1894, p. 175, 176) interpreted megacytic stages as prefission stages.

Contributions to our knowledge of the distribution of Dinophysis are to be found in the following papers, not specifying those previously mentioned in this section: — Abshagen (1908), Apstein (1893, 1902, 1905a, 1912), Aurivillius (1896a, b, 1899), Bergh (1881a), Bigelow (1915), Brandt (1898), van Breemen (1905), Breitfuss (1904, 1912), Broch (1908, 1910a,[1] b), Büse (1915), Bygrave (1911), Carazzi (1900), Carazzi and Grandori (1912), Carisso (1911),[1] Chun (1886), Clark (1905), Cleve (1894, 1897a, 1898, 1899a, b, 1900a, c, d, e, 1901a, c, 1902a, 1903a, b, 1905a, b), Cleve, Ekman, and Pettersson (1901), Cori and Steuer (1901), Cunha and Fonseca (1917), Czapek (1909), Dalla Torre (1889), Dixon and Joly (1898),[1] Driver (1907), Ehrenberg (1840b), Entz (1884, 1902a, b, 1905, 1907), Faria and Cunha (1917), Forti (1906, 1922), van Goor (1923), Gough (1906, 1907), Gräf (1909), Gran (1900, 1902,[1] 1915), Gruber (1884, 1888), Hensen (1887, 1890, 1895, 1911), Herdman and Riddell (1913), Herdman, Thompson, and Scott (1897), Hjort and Gran (1899, 1900), Imhof (1886), Jörgensen (1905), Karsten (1905, 1906), Kraefft (1908), Lauterborn (1894a), Lebour (1917a, b), Lemmermann (1900a, 1901a, 1905a), Levander (1894a, b, c,[1] 1901a, b, 1913, 1914), Lindemann (1924, 1925), Linko (1904, 1906, 1907), Lloyd (1925), Lohmann (1901, 1902, 1920), Mangin (1906, 1912, 1913, 1915), Mereschowsky (1879), Merkle (1910), Mielck (1911), Minkevich (1899), Möbius (1887, 1888a, 1893), Nathansohn (1908, 1909, 1910a), Nordgaard (1899, 1910), Okamura (1907,[1] 1912[1]), Ostenfeld (1895, 1898a, b, 1900, 1902, 1903, 1906, 1909, 1913a), Ostenfeld

[1] Contains figures by which the identifications may be verified.

and Paulsen (1904, 1911), van Oye (1921), Paulsen (1904, 1909, 1911a, b,[1] 1912), Pavillard (1912), Petersen (1897), Pouchet and Guerne (1885), Rauschenplat (1900), Redeke and van Breeman (1903), Reinhard (1910), Schiller (1911a, b, 1912), Schröder (1900a, b, 1906b, 1909), Schütt (1890, 1893), Schussnig (1914), Steuer (1910), Storrow (1913), Stüwe (1909), Tempère (1898), Vanhöffen (1897a,[1] b), Walther (1893), Whitelegge (1891), Wright (1907), and Zernow (1904). Of these papers only the following contain figures by means of which the accuracy of the determinations may be judged: — Broch (1910a), Carisso (1911), Dixon and Joly (1898), Gran (1902), Levander (1894c), Okamura (1907, 1912), Paulsen (1911b), and Vanhöffen (1897a). Forti (1922) reproduced previously published figures. Due to the great difficulties in the determination of several species and to the broad concept of species held by many investigators, much of the data on the distribution should be accepted tentatively.

References to Dinophysis or minor contributions to our knowledge of this genus are also found in Balbiani (1884a, c), Beauregard and Galippe (1880), Bergh (1882, 1884), Bles (1892), Brandt (1883), Bütschli (1885a), Buhigas (1918), Calkins (1902), Chun (1897), Daday (1884), Dakin (1908), Doflein (1909, 1911, 1916), Dogiel (1906), Entz (1909), Forti and Issel (1923), Goldschmidt (1907), Gran (1905, 1908, 1912a, b), Hensen (1891), Hjort (1911), Klebs (1884, 1885), Lawessan (1882), Lankester (1885), Lebour (1922), Leuckart (1861), Maggi (1874, 1880a, b), Nathansohn (1910b), Oltmanns (1922), Pavillard (1915a), Pouchet (1882, 1885a), Pritchard (1845, 1861), Stein (1878), Torrey (1902), Wallengren and Hennig (1911), West (1916), and Willey and Hickson (1909). Pavillard (1923a) gives a critical review of Jörgensen's (1923) important paper on this group.

It may also be mentioned that Gourret (1883, p. 74) rejected Amphidinium as a distinct genus and united it with Dinophysis.

The following typographical errors in the spelling of the name Dinophysis have been found by us: — Dixophysis Kofoid and Michener (1911) and Dynophysis van Oye (1921).

Adaptive and Systematic Value of the Characters. Principles used in the Description of the Species

The species of Dinophysis are limited largely to tropical, subtropical, and warm-temperate waters of low buoyancy. Nevertheless, most of them are characterized by the fact that the body (theca) is more or less simple in shape, such as lenticular (Figure 35: 1, 6), bilaterally flattened, ellipsoidal (Figure 32: 13),

[1] Contains figures by which the identifications may be verified.

ovoidal (Figure 31: 7), obovoidal (Figure 32: 6), etc. Only in one group of species, viz., in the CAUDATA group, *e.g.*, in *D. caudata* and *D. miles*, does the body show adaptations to flotation in the form of pronounced elongation and protuberances. In *D. miles*, a species occurring in tropical seas, the capacity of flotation is further increased during the period of binary fission by the fact that the schizonts form a wheel-like colony, a phenomenon that facilitates the remaining of the asymmetrical specimens in the horizontal position in which they offer a maximum surface of resistance (Weber-van Bosse, 1901, pl. 17, fig. 3). In *D. caudata* two specimens have been found to adhere to each other for some time following binary fission. The species that have a body more or less simple in shape maintain themselves in the upper strata of the sea by the same means as those found in Phalacroma (see p. 64). It may be mentioned, however, that in Dinophysis the anterior cingular list is, on the average, somewhat wider, that in some species (Plate 5, fig. 7) the left sulcal list and the posterior sail (or sails) are very large, and that the parasagittal lists along the dorsal margin of the body very seldom are present. Just as in Phalacroma, the species of Dinophysis that are endogenetic in cold waters (*D. acuminata, D. acuta, D. arctica, D. cuneiformis, D. granulata, D. norvegica, D. semen, D. sphaerica, D. ventricosa*, and *D. vertex*) are characterized by the relatively small size of their lists. With regard to the spiral swimming the same adaptations are found in Dinophysis and Phalacroma.

All the external characters have been considered and utilized in the establishment of the species; nevertheless, as in Phalacroma, a number of the specific separations should be regarded as tentative. This is true not only among the species of relatively simple organization, such as the members of the ACUTA group, but also among the highest-developed forms, *e.g.*, the representatives of the CAUDATA and HASTATA groups. It is due to the profound fluctuations that sometimes occur in several of the most important characters, *e.g.*, in the size and shape of the body and in the size, shape, and structure of the left sulcal list and of the posterior sail (or sails). As examples of striking variations in the size of the body, *Dinophysis hastata* and *D. uracantha* (Figure 32, 35) may be mentioned; profound variations in the shape of the body are well illustrated by *D. hastata, D. swezyi*, and *D. caudata* (Figure 32, 39, 44); variations in the shape of the left sulcal list by *D. swezyi* (Figure 39); variations in the shape and structure of the posterior sail by *D. hastata* (Figure 32). Jörgensen (1923, fig. 30–37) gives a good illustration of the wide amplitude of variation that might characterize a species of this genus. *Dinophysis hastata*, although highly differentiated, includes specimens that have the habitus characteristics of Dinophysis and specimens that look like

rather typical representatives of Phalacroma (Figure 33). The characters most variable within the species are those which have also been most profoundly modified within the genus as a whole, and it is largely upon them that the subdivisions of the genus have been founded.

In the descriptions of the species the same (five) principles have been applied as in Phalacroma.

Of the eight principles followed in the diagnoses of the species of Phalacroma, 1, 2, 3, 6, 7, and 8 are followed also in Dinophysis. If not otherwise mentioned, the epitheca is not visible above the anterior cingular lists, and the cingular lists are more or less funnel-like (inclined anteriorly) and subequal or the anterior is but slightly wider than the posterior; furthermore, the anterior cingular list is ribbed and the posterior is without ribs. The methods of measuring lengths, proportions, and angles are shown in Figure 29.

Subdivisions. Relationships among the Species

Dinophysis, like Phalacroma, exhibits a marked diversity of structural types, proceeding from small, simple, and undifferentiated forms such as *Dinophysis exigua* (Figure 30), closely related to the members of the primitive Rotundatum group of Phalacroma, to highly specialized ones such as *Dinophysis miles* (Cleve, 1900b, fig. 1a) and *D. jörgenseni* (Figure 42: 3–8). On the other hand, while the species of Phalacroma without very great difficulty can be arranged into several groups, all of which probably represent different evolutionary lines, Dinophysis does not readily yield to a similar analysis. Accordingly, the forty-one presumably valid species of the latter cannot with certainty be divided into more than three groups. Two of these include quite heterogeneous elements, and a further subdivision is desirable. However, attempts in this direction have not proved successful. The reason for this failure is largely the independent materialization in the various evolutionary lines of "tendencies" that were inherent in, but not morphologically expressed by, the simpler common ancestors. In other words, the obstacles were the same as in the genus Histioneis.

The three groups recognized in Dinophysis are as follows: —

1. Acuta group: — *D. exigua*, sp. nov., *D. punctata* Jörgensen, *D. semen* Meunier, *D. granulata* Cleve, *D. recurva*, nom. sp. nov., *D. arctica* Mereschowsky, *D. acuminata* Claparède and Lachmann, *D. baltica* (Paulsen) nobis, *D. sphaerica* Stein, *D. similis*, sp. nov., *D. ovum* Schütt, *D. okamurai*, sp. nov., *D. reniformis* (Pavillard) nobis, *D. sacculus* Stein, *D. ellipsoides* Kofoid, *D. dens* Pavillard, *D. truncata* Cleve, *D. fortii* Pavillard, *D. vertex* Meunier, *D. ventricosa* Claparède and

Lachmann, *D. norvegica* Claparède and Lachmann, *D. schröderi* Pavillard, *D. acuta* Ehrenberg, and *D. cuneiformis* Meunier (Figure 30; Jörgensen, 1923, fig. 28; Meunier, 1910, pl. 3, fig. 47, 48; Cleve, 1899c, pl. 4, fig. 7; Pavillard, 1916, pl. 3, fig. 6; Mereschowsky, 1879, pl. 11, fig. 19; Claparède and Lachmann, 1858, pl. 20, fig. 17; Paulsen, 1908, fig. 17; Figure 31: 3, 4 and 1, 2; Schütt, 1895, pl. 1, fig. 6, Figure 31: 5; Pavillard, 1905, pl. 3, fig. 10; Stein, 1883, pl. 20, fig. 10; Kofoid, 1907b, pl. 33, fig. 56; Pavillard, 1916, pl. 3, fig. 1; Cleve, 1900f, fig. 7; Pavillard, 1916, pl. 3, fig. 4; Meunier, 1910, pl. 14, fig. 29, 30; Claparède and Lachmann, 1858, pl. 20, fig. 20; Paulsen, 1907, fig. 1a; Figure 31: 6; Paulsen, 1907, fig. 1b; Meunier, 1910, pl. 14, fig. 31, 32).

2. Hastata group: — *D. pusilla* Jörgensen, *D. hastata* Stein, *D. alata* Jörgensen, *D. rudgei* Murray and Whitting, *D. uracantha* Stein, *D. urceolus*, sp. nov., *D. monacantha*, sp. nov., *D. trapezium*, sp. nov., *D. swezyi*, sp. nov., *D. collaris* Kofoid and Michener, *D. schütti* Murray and Whitting, *D. nias* Karsten, *D. jörgenseni*, sp. nov., and *D. triacantha* Kofoid (Jörgensen, 1923, fig. 44; Figure 32, 33; Jörgensen, 1923, fig. 45; Murray and Whitting, 1899, pl. 31, fig. 9; Figure 35, 37: 1 and 2, 3; 38: 2, 3; 39; 38: 1, 40, 42: 1, and 3–8 and 2).

3. Caudata group: — *D. caudata* Saville-Kent, *D. tripos* Gourret, and *D. miles* Cleve (Figure 44; Jörgensen, 1923, fig. 38, 39; Cleve, 1900b, fig. 1a).

1. Acuta group (for references, see above): — Body of somewhat varying shapes, usually ellipsoidal, ovate to subovate in lateral outline, never with posterior peduncle. Accessory sails and lists not present.

The twenty-four species referred by us to this group have been arranged above, as far as possible, according to similarities. The series begins with small, simple, ellipsoidal, and usually symmetrical forms (*Dinophysis exigua, D. punctata, D. semen, D. granulata,* and *D. recurva*; Figure 30; Jörgensen, 1923, fig. 28; Meunier, 1910, pl. 3, fig. 47, 48; Cleve, 1899c, pl. 4, fig. 7; Pavillard, 1916, pl. 3, fig. 6), and ends with moderately large forms, the bodies of which are somewhat asymmetrical and elongated, and narrowly rounded to subacute posteriorly (*D. vertex, D. ventricosa, D. norvegica, D. schröderi, D. acuta,* and *D. cuneiformis;* Meunier, 1910, pl. 14, fig. 29, 30; Claparède and Lachmann, 1858, pl. 20, fig. 20; Paulsen, 1907, fig. 1a; Figure 31: 6; Paulsen, 1907, fig. 1b; Meunier, 1910, pl. 14, fig. 31, 32). Between these extremes we have a practically continuous series of intermediate forms (*D. arctica, D. baltica, D. ovum,* and *D. fortii;* Mereschowsky, 1879, pl. 11, fig. 19; Paulsen, 1908, fig. 17; Schütt, 1895, pl. 1, fig. 6; Pavillard, 1916, pl. 3, fig. 4). Indeed, the transitions between the members of the extreme groups as well as between the members of the intermediate group are so gradual

that delimitations of species are extremely difficult. *D. acuminata* (Claparède and Lachmann, 1858, pl. 20, fig. 17) agrees fairly closely with *D. arctica*, but is characterized by one or more small protuberances on the posterior end of the body. *D. similis* (Figure 31: 1, 2), which represents a small side branch characterized by the reduction of the posterior main rib of the left sulcal list, is structurally closely related to *D. sphaerica* (Figure 31: 3, 4), which in its turn is close to *D. ovum* (Schütt, 1895, pl. 1, fig. 6). *D. okamurai* (Figure 31: 5), which presumably also is closely related to *D. ovum*, is characterized by the concavity of the anterior portion of the ventral margin of the hypotheca. *D. reniformis* and *D. sacculus* (Pavillard, 1905, pl. 3, fig. 10; Stein, 1883, pl. 20, fig. 10) as well as *D. dens* and *D. truncata* (Pavillard, 1916, pl. 3, fig. 1; Cleve, 1900f, fig. 7) form short side branches. The first two species are characterized by the slight, but distinct bending of the body, the last two by the subtrapeziform lateral outline of the body. These four species probably originated from an ancestral form resembling *D. ovum* or *D. fortii* (Pavillard, 1916, pl. 3, fig. 3, 4). *D. ellipsoides* (Kofoid, 1907b, pl. 33, fig. 56) is probably closely related to *D. reniformis*.

This group corresponds to Pavillard's (1916) sections Acuta, Sacculus, and Sphaerica, and to Jörgensen's (1923) sections Acutae, Ovum, and Sphaericae.

2. Hastata group (for references, see above): — Body of varied shapes, rounded, ovate, subovate, or rounded subtrapeziform in lateral outline, without posterior peduncle. With one or two posterior sails and sometimes with parasagittal lists along dorsal side of hypotheca.

The fourteen species of this group are arranged above, as far as possible, according to structural similarities. The first three of them, viz., *Dinophysis pusilla*, *D. hastata*, and *D. alata* (Jörgensen, 1923, fig. 44; Figure 32, 33; Jörgensen, 1923, fig. 45) are structurally, and presumably also genetically, very closely related and appear to form a natural unit. Their most characteristic common features are as follows: — (*1*) only one posterior sail is present, and this is located ventrally to the midline and directed somewhat ventrally; (*2*) the ventral margin of the left sulcal list is nearly straight or more or less convex. *D. pusilla*, which is the most primitive member of this group, is a very small form, subcircular in lateral outline, and its posterior sail is small and lacks structural differentiation. In *D. hastata* and *D. alata* the body is somewhat elongated, the longitudinal axis deflected posteroventrally, and the posterior sail is fairly large and has a central rib or a central reticulation. Of these two species *D. alata* is the more highly differentiated, in so far as it has a wide parasagittal list along the dorsal side of the hypotheca. The remaining members of this group are structurally very close

to *D. pusilla*, *D. hastata*, and *D. alata*, but at the same time they presumably belong to different evolutionary lines. Of these species *D. uracantha* and *D. urceolus* (Figure 35, 37: 1) undoubtedly are very closely related. Their most important common characteristics are as follows: — (*1*) the longitudinal axis is somewhat deflected posterodorsally; (*2*) only one posterior sail is developed, and this is located somewhat dorsally to the midline and supported by marginal ribs; (*3*) the ventral margin of the left sulcal list is straight or nearly so. *D. monacantha*, *D. trapezium*, and *D. collaris* (Figure 37: 2, 3; 38: 2, 3; 38: 1) are variants of the same evolutionary type as the last two species. *D. monacantha* differs from these mainly in two respects, viz., its posterior sail is located on the midline and parasagittal lists are developed along the dorsal side of the hypotheca. *D. trapezium* is characterized especially by the fact that its left sulcal list is furnished with an accessory triangular lobe behind the posterior main rib; and *D. collaris* is distinguished from *D. trapezium* chiefly by having the accessory lobe and the posterior sail well balanced, of about the same size, shape, and structure. The last five species form in most respects a well-marked orthogenetic series. *D. swezyi* (Figure 39), which approaches *D. trapezium* in having the left sulcal list furnished with an accessory posterior lobe, differs strikingly from this as well as from the other previously discussed species in the more or less pronounced concavity of the ventral margin of its left sulcal list. In the last respect *D. swezyi* resembles *D. schütti*, *D. jörgenseni*, and *D. triacantha* (Figure 40; 42: 3–8; 42: 2), of which the last two are characterized especially by having two posterior sails, instead of one. On the other hand, in *D. nias* (Figure 42: 1), which undoubtedly is very close to *D. jörgenseni* as indicated by the fact that it has two posterior sails, the ventral margin of the left sulcal list is straight or nearly so. Finally, *D. rudgei* (Murray and Whitting, 1899, pl. 31, fig. 9) represents a small side branch, characterized by the primitive, subcircular lateral outline of the body and by the very heavy and large-meshed thecal reticulation. This branch probably split off near the base of the evolutionary scale of this group.

This group corresponds to the section Hastata of Pavillard (1916) and of Jörgensen (1923). Although it comprises at least three evolutionary lines, viz., the Pusilla, the Uracantha, and the Rudgei lines, its subdivision is hardly advisable at the present time.

3. Caudata group (Figure 44; Jörgensen, 1923, fig. 38, 39; Cleve, 1900b, fig. 1a): — Body strongly elongated, with posterior peduncle. Without accessory lists or sails.

Of the three species of this group, *Dinophysis caudata* (Figure 44) is the most

primitive, and *D. miles* (Cleve, 1900b, fig. 1a) is the most advanced. *D. tripos* (Jörgensen, 1923, fig. 38, 39) is structurally and presumably also genetically intermediate between these extreme types. This group corresponds to the section Homunculus of Pavillard (1916) and Jörgensen (1923).

Each of these three groups presumably has evolved independently from small, subrotund, and structurally undifferentiated forms, such as *Dinophysis exigua* (Figure 30: 1) in three diverging lines.

1. Acuta Group: — Of the twenty-four species referred to this group, only the following were found in the material of the Expedition: *Dinophysis exigua, D. sphaerica, D. similis, D. okamurai, D. fortii, D. norvegica,* and *D. schröderi.* Their arrangement is indicative of relationships.

Dinophysis exigua, sp. nov.

Figure 30

Diagnosis: — Body subellipsoidal in lateral outline, deepest near the middle; length: depth, 1.08–1.14: 1; symmetrical, or its longitudinal axis deflected posterodorsally at 1°–10°. Posterior cingular list 0.18–0.28 the length of body from apex; epitheca barely if at all visible above anterior cingular list. Cingular list inclined anteriorly at 30°–50°; the anterior sometimes somewhat wider than the posterior; structure unknown. Left sulcal list 0.50–0.60 the length of body; distance between R_1 and R_3 0.40–0.45 the length of body; R_2 is 0.15–0.17, R_3 is 0.37–0.50 the greatest depth of body; margin forms angle of 40°–55° at R_3; R_3 inclined posteriorly at 40°–50°. Structure of theca unknown, presumably not differentiated. Length, 28.9–30.4 μ.

Eastern tropical Pacific.

Description: — This is a small species, the body of which is subellipsoidal in lateral outline, deepest near the middle. The ratio between the length and the depth of the body is 1.12 (0.08–1.14): 1. Either the body is symmetrical, or its longitudinal axis is deflected posterodorsally at 1°–10°.

The epitheca is about 0.63 (0.58–0.67) as deep as the hypotheca and highest in the center; it is evenly, and moderately to rather strongly convex, and barely, if at all, visible above the anterior cingular list. The transverse furrow is flat or slightly convex, and its width is 1.0–1.5 the greatest height of the epitheca. The posterior cingular list is about 0.22 (0.18–0.28) the length of the body from the apex. The hypotheca is sometimes symmetrical (Figure 30: 1), sometimes more or less deflected posteroventrally (Figure 30: 2, 3) (see p. 240). Its dorsal, pos-

terior, and ventral margins are moderately convex and confluent. The posterior portion of the body is not, or but slightly, deeper than the anterior.

The cingular lists are subequal, or the anterior is somewhat wider than the posterior; the anterior is about 1.0–1.5 times wider than the transverse furrow and 0.21 (0.19–0.25) the greatest depth of the body; the anterior has an anterior inclination of 30°–50°, the posterior sometimes a little less; their structure is unknown. The right sulcal list is unknown. The left sulcal list is 0.50–0.60 as long as the body, and the distance between the anterior and posterior main ribs is 0.40–0.45 the length of the body. The anterior main rib is 0.20–0.21, the fission rib 0.15–0.17, and the posterior main rib 0.42 (0.37–0.50) the greatest depth of the body; behind the last rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is almost straight; at the posterior main rib it forms an angle of 40°–55°; behind the last-mentioned rib it is gently concave or straight. The main ribs of this list are of moderate strength, and not club-shaped or otherwise modified; the two anterior are straight or nearly so, the posterior is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.29–0.40 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 40°–50°. Except for the main ribs, this list appears to lack structure. There are no accessory lists or sails. The structure of the thecal wall is unknown.

Megacytic specimens were not recorded.

The dimensions of three specimens were measured.

FIGURE 30.— *Dinophysis exigua*, sp. nov., 1, 2, in left lateral view; 3, in right lateral view. 1, from type specimen. × 430. 1, 2, from Station 4545, surface; 3, from Station 4709, stomach of Salpa.

Dimensions: — Length of body, 28.9–30.4 μ (average, 29.6 μ; type, 29.6 μ). Greatest depth of body, 25.6–28.2 μ (average, 26.6 μ; type, 25.9 μ).

Variations: — This species varies mainly in the inclination of the longitudinal axis of the body, and in the inclination and relative width of the anterior cingular list.

Comparisons: — This species is established on drawings giving the lateral outlines of three specimens from the material of the Expedition. The description given above is thus incomplete in several respects. The following important char-

acters are unknown: — the shape of the body in dorsoventral view, the structure of the thecal wall, the structure of the cingular lists, and the shape and structure of the right sulcal list.

Dinophysis exigua is on the border line between Dinophysis and Phalacroma. It has some features that affiliate it with Dinophysis, viz., the narrowness of the epitheca, the strong anterior inclination of the cingular lists, and the posterodorsal inclination of the longitudinal axis of the hypotheca. The last peculiarity has not been found in any of the known species of Phalacroma, but it is characteristic of some species of Dinophysis, *e.g.*, *D. uracantha*, *D. schütti*, and *D. swezyi*. Compare also the shape of the left sulcal list in *D. exigua and D. uracantha*. On the other hand, *D. exigua* is not far removed from *Phalacroma parvulum* and its small, simple, and rounded relatives.

The structurally closest-known relative of *Dinophysis exigua* probably is the species established by Ehrenberg (1840a, p. 151, pl. 4, fig. 15) under the name of *D. michaelis* and later figured by Lohmann (1908a, fig. 7: 43, p. 201) under the name of *D. rotundata;* Lohmann's as well as Ehrenberg's specimens were from the Bay of Kiel. These two species are so similar that their specific separation should be regarded as tentative. They have been separated by us, since *D. michaelis* appears to be somewhat larger (about 52 μ, according to Lohmann's figure, as compared with 28.9–30.4 μ) and narrower. Another structurally close relative is *D. lenticula* Pavillard (*non* [Bergh] Daday, 1888), which is most easily distinguished by the shape of its left sulcal list (see also *Phalacroma parvulum*, the section on comparisons).

Occurrence: — *Dinophysis exigua* is recorded at two of the 127 stations. Of these two stations one (4709) is on the fourth line of the Expedition and in the South Equatorial Drift; the other (4545), the type locality, is on the sixth line and in the Mexican Current. At Station 4709 one specimen was found in the stomach of a Salpa taken in a surface haul; the other record (two specimens) refers to a surface haul.

The surface temperatures of these two stations were 72° and 79°, respectively.

The frequency is less than 1% in both cases.

Dinophysis sphaerica Stein

Figure 31: 3, 4

Dinophysis sphaerica Stein, 1883, *partim*, pl. 20, fig. 3, 4. Daday, 1888, p. 99, 104. *non* Schütt, 1895, p. 13, 64, 119, pl. 1, fig. 7: 1, 2. Aurivillius, 1898a, p. 256, 348, 368, 418; 1899, p. 33, 64. Lemmermann, 1899a, *partim*, p. 373; 1901a, p. 375. Murray & Whitting, 1899, p. 331, tab. 1, 2, 4–6, 8, 9. Schröder, 1900a, p. 19. Gran, 1900, p. 43. Ostenfeld & Schmidt, 1901, p. 170. Schmidt, 1901, p. 138. Entz, 1902b, p. 94; 1905, p. 111. Cleve, 1903b, p. 344. Karsten, 1905, p. 59, 62, 63; 1906,

p. 218; 1907, p. 233. Zacharias, 1906, p. 530. Paulsen, p. 13, 16, fig. 15. Gräf, 1909, p. 139. Hensen-Ostenfeld, 1913, p. 141. *non* Pavillard, 1916, p. 47, 60. Jörgensen, 1923, p. 11, 23, 44, fig. 29. Lebour, 1925, p. 82, fig. 21c.

?Phalacroma sphaericum Zacharias, 1906, p. 530.

Diagnosis: — Body ovate to subellipsoidal in lateral outline, deepest in or somewhat behind the middle; length: depth, 1.17–1.43: 1; symmetrical or with but slight posteroventral inclination. Anterior cingular list 1.4–1.7 times wider than transverse furrow. Left sulcal list 0.52–0.66 the length of body; distance between R_1 and R_3 0.44–0.58 the length of body; R_2 is 0.18–0.33, R_3 is 0.23–0.41 the greatest depth of body; margin forms angle of 80°–90° at R_3; R_3 inclined posteriorly at 5°–15°; besides the three main ribs this list has numerous anastomosing cross-ribs. Theca finely and closely areolate. Length, 44.5–47.0 μ.

Probably widely distributed in tropical, subtropical, and warm-temperate seas, seldom in colder regions.

Description: — This is a rather small species, the body of which is ovate to subellipsoidal in lateral outline, and deepest in or somewhat behind the middle. The ratio between the length and the depth of the body is 1.17–1.43: 1; in Stein's (1883, pl. 20, fig. 3, 4) specimens this ratio is 1.20–1.43: 1; in our specimens it is 1.17–1.31: 1. The longitudinal axis either is perpendicular to the transverse furrow, or it is inclined posteroventrally at 1°–5°.

The epitheca is 0.43–0.55 as deep as the hypotheca, of moderate convexity, highest in or near the center, and not visible above the anterior cingular list. The transverse furrow is flat or somewhat convex, and its width is 1.0–2.0 the greatest height of the epitheca. The posterior cingular list is 0.12–0.19 the length of the body from the apex. The hypotheca is symmetrical or almost so. The dorsal and ventral margins are subuniformly, and gently to moderately or rather strongly convex; or they are somewhat flattened anteriorly. The postmargin is evenly and rather strongly convex, and confluent with the dorsal and ventral margins. The posterior portion of the body may be of about the same depth as the anterior (Stein, 1883, pl. 20, fig. 3), but usually it is more or less strikingly deeper (Figure 31: 3).

The anterior cingular list is 1.4–1.7 times wider than the transverse furrow and 0.18–0.29 the greatest depth of the body; it has a well-developed funnel shape, being inclined anteriorly at 45°–60°; and on each valve it is furnished with about ten to twenty simple, straight, and almost equidistant ribs. The posterior cingular list has about the same inclination as the anterior and appears always to lack structural differentiation. In our specimens it is about as wide as or slightly narrower than the anterior, but in the specimens figured by Stein (1883, pl. 20, fig.

3, 4) it is very narrow, only about 0.25 the width of the anterior. It should be noticed, however, that Stein (1883) made this list very narrow in almost all his figures of species of Dinophysis. The right sulcal list extends to or slightly beyond the fission rib of the left sulcal list and is subtriangular, decreasing gradually in width posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is 0.58 (0.52–0.66) the length of the body, and the distance between the anterior and posterior main ribs is 0.51 (0.44–0.58) the length of the body. The anterior main rib is 0.20–0.28, the fission rib 0.18–0.33, and the posterior main rib 0.23–0.41 the greatest depth of the body; in the specimens examined by us the corresponding values are 0.20–0.22, 0.18, and 0.23–0.24, respectively; in the specimens figured by Stein (1883, pl. 20, fig. 3, 4) they are 0.25–0.28, 0.29–0.33, and 0.31–0.41, respectively. Behind the posterior main rib this list decreases sud-

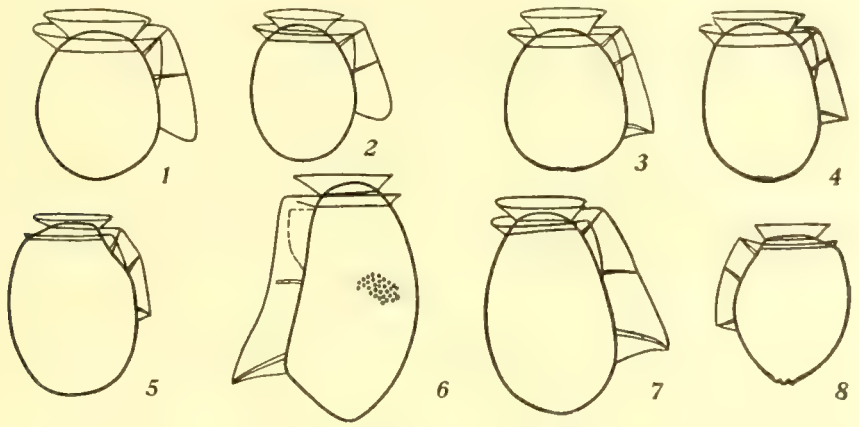

FIGURE 31. — 1, 2, *Dinophysis similis*, sp. nov., right lateral view (2, possibly somewhat tilted). × 430. 1, from Station 4701 (300–0 fathoms); 2, from Station 4691 (300–0 fathoms). 3, 4, *Dinophysis sphaerica* Stein, right lateral view. × 430. 3, from Station 4697 (300–0 fathoms); 4, from Station 4711 (300–0 fathoms). 5, *Dinophysis okamurai*, sp. nov., right lateral view of type specimen. × 430. Station 4673 (300–0 fathoms). 6, *Dinophysis schröderi* Pavillard, left lateral view; structure of thecal wall indicated only. × 430. Station 4574, surface. 7, *Dinophysis fortii* Pavillard, right lateral view. × 430. Station 4667 (300–0 fathoms). 8, *Dinophysis norvegica* Claparède and Lachmann, left lateral view. × 430. Station 4638 (300–0 fathoms).

denly in width. Between the anterior and posterior main ribs the free margin of this list is almost straight, or gently to moderately convex; at the posterior main rib it forms an angle of 80°–90°; behind this rib it is almost straight or gently concave. The main ribs are of moderate strength, and not club-shaped or otherwise modified; the anterior two are straight or almost so; the posterior one may be straight but usually is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.30–0.38 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 5°–

15°. Besides the three main ribs, this list has numerous anastomosing cross-ribs (Stein, 1883, pl. 20, fig. 3, 4). There are no accessory lists or sails. The thecal wall is finely and closely areolate, and at least sometimes furnished with scattered pores; compare figure 3 and figure 4 of Stein's (1883) Plate 20.

Megacytic specimens have not been recorded.

The dimensions of two of our specimens and of the specimens figured by Stein (1883, pl. 20, fig. 3, 4) were measured.

Dimensions: — Our specimens: length of body, 44.5–47.0 μ. Greatest depth of body, 35.9–38.1 μ. The size of the specimens represented by Stein (1883, pl. 20, fig. 3, 4) is unknown. Judging by Stein's (1883) information about the magnifications of his figures, given in an introductory remark to the explanations of the plates, the lengths of these specimens were somewhere between 52.2 μ and 86.5 μ.

Variations: — This species, as here conceived, is rather variable. The size of the body, the shape of the hypotheca, the width of the cingular lists, and the size of the left sulcal lists are the most variable characters.

Comparisons: — *Dinophysis sphaerica*, as conceived by Stein (1883, pl. 20, fig. 3–9), is certainly not a natural systematic unit. Indeed, the five specimens figured under this name by him probably belong to at least three different species. This fact was pointed out first by Ostenfeld and Schmidt (1901) and later by Schmidt (1901), Paulsen (1908), Pavillard (1916), and Jörgensen (1923), who, in their references to Stein's (1883) figures of this species, mention only his Plate 20, figure 3 and 4 (see also *D. punctata* Jörgensen, 1923, p. 23). Although the two specimens represented by Stein's (1883) Plate 20, figure 3 and 4, are rather different, and the question as to whether or not they belong to the same species must be regarded as open, we have considered it most advisable to accept, preliminarily, the decision of Ostenfeld and Schmidt (1901). The specimen represented by Stein's (1883) Plate 20, figure 4, is regarded as the type of *D. sphaerica s. str.*

Of the two specimens found by us in the material of the Expedition and figured in the present paper, one (Figure 31: 3) shows, in the shape of its body, a rather striking resemblance to the type specimen; the other (Figure 31: 4) approaches in the same respect the specimen represented by Stein's (1883) Plate 20, figure 3. Both of our specimens differ conspicuously from Stein's (1883) specimens in their wider posterior cingular list and in their narrower left sulcal list. We are not able to judge the significance of these differences. However, it seems far from improbable that the difference in the width of the posterior cingular list is due to the incomplete observation of this structure by Stein (1883), since this list is very narrow in almost all the figures of species of Dinophysis to be found in

Stein's (1883) iconography. Reference should also be made to the rather striking similarity in the shape of the body, between one of our specimens (Figure 31:3) and the specimen represented by Stein's (1883) Plate 20, figure 9.

The structurally closest-known relatives of *Dinophysis sphaerica* are *D. ovum* and *D. similis*. Indeed, the specific separation of these three forms should be regarded as tentative (see *D. similis*, the section on comparisons). *D. sphaerica* differs from *D. ovum* mainly in having the anterior cingular list ribbed and in the shape of the posterior portion of the left sulcal list. From *D. similis* it differs mainly in having the posterior main rib of the left sulcal list well developed, about as long as or somewhat longer than the fission rib of this list, and in having the posteroventral portion of this list angular instead of rounded to rounded angular. Other structurally close relatives of *D. sphaerica* are *D. lenticula* Pavillard (*non* [Bergh] Daday, 1888) and *D. punctata*. *D. lenticula* differs from *D. sphaerica* mainly in lacking ribs in the anterior cingular list and in having the ventral margin of the left sulcal list strongly recurved to the right (Pavillard, 1916, pl. 3, fig. 6). *D. punctata* is characterized by its smaller size and by the faint structure of its thecal wall.

Synonymy: — The name of *Dinophysis sphaerica* was first applied by Stein (1883, pl. 20, fig. 3–9) to a compound species. Later it was used in a restricted sense by Ostenfeld and Schmidt (1901), Schmidt (1901), Paulsen (1908), Pavillard (1916), and Jörgensen (1923) (see the previous section). Of the rather great number of writers who have used this name, only the following, besides Stein (1883), give descriptions or figures by means of which their determinations of this species may be checked: — Schütt (1895), Paulsen (1908), Okamura (1912), Pavillard (1916), Jörgensen (1923), and Lebour (1925). With regard to *D. sphaerica* of Schütt (1895), Pavillard (1916), and Jörgensen (1923), see *D. similis*, the sections on comparisons and synonymy. The figures of this species given by Paulsen (1908, fig. 15) and Lebour (1925, fig. 21b) are reproductions of Stein's (1883) Plate 20, figure 3. The figure given by Okamura (1912, pl. 5, fig. 85) under the name of *D. sphaerica* is too incomplete for certainty of specific determination. However, the small size of the figured specimen, 35.8 μ, seems to indicate that *D. sphaerica* Okamura (1912) is not identical with *D. sphaerica* Stein. Zacharias (1906, p. 530) records a species from the Gulf of Naples under the name of *Phalacroma sphaericum* Stein. This is probably a *lapsus pennae* for *Dinophysis sphaerica*, a name also used by Zacharias (1906), but no data bearing on this question are available. Entz (1902b, 1905) writes *sphaeriaca* instead of *sphaerica*. Our bibliographical list of *D. sphaerica* should be regarded as rather uncertain,

since the great difficulties in determining this and closely related species make errors or at least diversity in the assignments of specimens of these species very probable.

Occurrence: — *Dinophysis sphaerica* is recorded at four of the 127 stations. There are 1, 0, 0, 2, 1, and 0 stations on the six lines of the Expedition. Of these four stations, one (4619) is in the Panamic Area; one (4697) is in the Easter Island Eddy; and two (4711, 4720) are in the South Equatorial Drift. There are two records from surface waters (from Salpa stomachs; Stations 4619, 4720), and two from hauls from 300–0 fathoms (Stations 4697, 4711).

The temperature range of these four stations at the surface was 75°–79°; the average was 76.2°.

At one station (4720) the frequency is 4%, at one station (4619) 1%, and at the two remaining stations less than 1%.

Stein (1883) recorded this species "aus dem Atlantischen Meer." In the Arctic Ocean it has not been recorded more than once, viz., by Aurivillius (1899), on the north side of Spitzbergen, in Hinlopen Strait, lat. 80° 31′ N. Aurivillius (1898a) also found it on four occasions in the Skager Rak, on the west coast of Sweden. Murray and Whitting (1899) reported it from thirteen stations in the Atlantic, between lat. 44° 30′ N. and lat. 18° 20′ N., and between long. 19° W. and long. 64° W.; Gräf (1909) found it at lat. 35° 57′ N., long. 7° 50′ W. At the Cape of Good Hope it was found by Karsten (1906). From the Mediterranean it has been recorded by the following investigators: — from Naples by Daday (1888) and Zacharias (1906); from the Adriatic by Entz (1902b, 1905). In the Red Sea it was found by Ostenfeld and Schmidt (1901), and Cleve (1903b); in the Gulf of Aden, by Ostenfeld and Schmidt (1901); in the Indian Ocean, at lat. 34° 13′ S., long. 80° 30′ E., by Karsten (1907); in the Antarctic Ocean, at lat. 63° 16′ S.–63° 32′ S., long. 57° 51′ E.–54° 46′ E., by Karsten (1905); and in the Gulf of Siam, by Schmidt (1901). As stated in the last section, it is doubtful whether or not the form recorded by Okamura (1912) from Japanese waters under the name of *Dinophysis sphaerica* is referable to this species.

Karsten (1905, 1907) reported this species as taken with closing net at the following stations: — Station 151, lat. 63° 32′ S., long. 54° 46′ E., 100–10 m. and 300–100 m.; Station 152, lat. 63° 15′ S., long. 57° 51′ E., 80–60 m.; Station 169, lat. 34° 13′ S., long. 80° 30′ E., 60–40 m. All the specimens recorded were reported as living. Most of the other records mentioned above probably refer to surface hauls.

According to the writers who have contributed to our knowledge of the

distribution of this species, it occurs in waters of the following temperatures and salinities. Aurivillius (1898a):— temperature: range, 54.1°–65.6°; mean of three observations, 60.2°; salinity: range, 24.0–29.5; mean of three observations, 26.3. Aurivillius (1899): — temperature, 36.4°; salinity, 33.93. Murray and Whitting (1899): — temperature: range, 58°–79°; mean of thirteen observations, 70.0°. Ostenfeld and Schmidt (1901): — temperature: range, 72.0°–80.2°; mean of four observations, 77.2°. Cleve (1903b): — temperature, 84.6°; salinity, 39.92.

Unfortunately our knowledge of the distribution of *D. sphaerica* must be regarded as rather uncertain, since this species, on account of its simple structure, is very easily confused with some closely related forms. Of the authors who have recorded this species, only Stein (1883) and Okamura (1912) give descriptions or figures by means of which their determinations may be checked. Ostenfeld and Schmidt (1901), and Schmidt (1901) refer to Stein's (1883) Plate 20, figure 3 and 4 (see above, the sections on comparisons and synonymy).

This species has been recorded from waters of very different temperatures. However, it probably is a warm-water form and not endogenetic in the Skager Rak (see Aurivillius, 1898a; Gran, 1900; and Hensen-Ostenfeld, 1913) and in the Arctic Ocean. We are not in the position to discuss the question as to whether or not it is endogenetic in the Antarctic Ocean.

Dinophysis similis, sp. nov.

Figure 31: 1, 2

Dinophysis sphaerica Schütt, 1895, p. 13, 119, *non* p. 64, pl. 1, fig. 7: 1, 2. Pavillard, 1916, p. 47, 60. Jörgensen, 1925, p. 11, 23, 44, fig. 29.

Diagnosis: — Body subcircular to ovate or subellipsoidal in lateral outline, deepest in or just behind the middle, and 1.03–1.29 times longer than deep; symmetrical or its longitudinal axis is inclined posteroventrally at about 1°–10°. Anterior cingular list 1.4–2.0 times wider than transverse furrow. Left sulcal list 0.50–0.57 the length of body, of subuniform width throughout the greater portion of its length; R_1 and R_2 subequal, 0.19–0.30 the greatest depth of body; R_3 absent or rudimentary (very short); posteroventrally this list is rounded or forms a more or less rounded angle of 50°–55°. Theca finely and closely areolate. Length, 43.0–62.0 μ.

Probably widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — This is a rather small to medium-sized species, the body of which is subcircular to ovate or subellipsoidal in lateral outline, and deepest in or

somewhat behind the middle. The ratio between the length and the depth of the body is 1.03–1.29: 1; in Schütt's (1895, pl. 1, fig. 7: 1) and Jörgensen's (1923, fig. 29) specimens, this ratio is 1.09: 1 and 1.03: 1, respectively; in our specimens it is 1.19–1.29: 1. The longitudinal axis either is about perpendicular to the transverse furrow (Figure 31: 1, 2), or it has a posteroventral inclination of about 1°–10°, as in the specimens figured by Schütt (1895) and Jörgensen (1923).

The epitheca is 0.42–0.54 as deep as the hypotheca, of moderate convexity, highest in or near the center, and not visible above the anterior cingular list. The transverse furrow is flat or somewhat convex, and its width is 1.5–2.0 the greatest height of the epitheca. The posterior cingular list is 0.14–0.17 the length of the body from the apex. The hypotheca either is symmetrical (Figure 31: 1, 2), or somewhat inclined posteroventrally (see above). The dorsal and ventral margins are subuniformly, and moderately to rather strongly convex; sometimes (Schütt, 1895, pl. 1, fig. 7: 1; Jörgensen, 1923, fig. 29) the ventral margin is less convex than the dorsal. The postmargin is evenly and rather strongly convex, and confluent with the dorsal and ventral margins. The posterior portion of the body may be of about the same depth as the anterior (Figure 31: 2), but usually it is more or less strikingly deeper.

The cingular lists are subequal, or the posterior is slightly narrower than the anterior; the anterior is 1.4–2.0 times wider than the transverse furrow and 0.22–0.29 the greatest depth of the body. Both these lists are funnel-shaped, being inclined anteriorly at 30°–40°. The anterior has simple, straight, and almost equidistant ribs, about 10–15 on each valve; the posterior appears always to lack structural differentiation. The right sulcal list extends to or slightly beyond the fission rib of the left sulcal list and is subtriangular, decreasing gradually in width posteriorly; anteriorly it is about as wide as or somewhat wider than the transverse furrow. The left sulcal list is 0.50–0.57 the length of the body and of subuniform width throughout the greater part of its length. In the specimens figured by Schütt (1895) and Jörgensen (1923) the anterior main rib and the fission rib are about 0.19 the greatest depth of the body; in our specimens the corresponding value is 0.28–0.30. The posterior main rib is absent, or rudimentary and short; it is "usually indistinct, or only distinct for a short inner portion" (Jörgensen, 1923, p. 23, fig. 29). Posteriorly the left sulcal list is rounded (Jörgensen, 1923, fig. 29), or it forms a more or less rounded angle of about 50°–55°; one of our specimens (Figure 31: 2) agrees in this respect rather closely with Schütt's (1895) Plate 1, figure 7: 1; the other (Figure 31: 1) with Schütt's (1895) Plate 1, figure 7: 2. The ventral margin of this list is almost straight or gently convex. The main

ribs are straight or almost so, and not club-shaped or otherwise modified. In some specimens this list is without structure except for the anterior two main ribs; sometimes (Schütt, 1895, pl. 1, fig. 7: 2) its posterior half is finely reticulated. There are no accessory lists or sails. The thecal wall is finely and closely areolate and has scattered pores.

Megacytic specimens have not been recorded.

The proportions of two of our specimens and of the specimens figured by Schütt (1895) and Jörgensen (1923) were measured.

Dimensions: — Our specimens: Length of body, 43.0–46.4 μ. Greatest depth of body, 33.2–38.5 μ. The specimen figured by Schütt (1895, pl. 1, fig. 7: 1) was 62.0 μ long and 57.0 μ deep. The type specimen, as figured by Jörgensen (1923, fig. 29) was 61.0 μ long and 59.0 μ deep. According to Jörgensen (1923, p. 24) this species is "as a rule" 57–60 μ long and 55–57 μ deep.

Variations: — Jörgensen (1923), who examined a great number of specimens, does not indicate by any statement that he had found this species to be variable. Furthermore, the specimens figured by Schütt (1895) and Jörgensen (1923) are very similar. These circumstances seem to indicate that this species is rather constant. The specimen represented by our Figure 31: 2 should be regarded as aberrant. The following characters are the most variable: the size of the body, the inclination of the longitudinal axis of the body, the relative depth of the body, and the shape and structure of the posterior portion of the left sulcal list.

Comparisons: — This species is established on the specimens figured by Schütt (1895, pl. 1, fig. 7) and Jörgensen (1923, fig. 29) under the name of *Dinophysis sphaerica* Stein, and on two specimens found in the material of the Expedition. Its most outstanding characteristics are the absence or strong reduction of the posterior main rib of the left sulcal list and the rounded to rounded-angular shape of the posteroventral portion of this list. Before Jörgensen's (1923) paper was available, we were inclined to consider these peculiarities as signs of recent binary fission (see Figure 46: 2, of *D. caudata* f. *acutiformis*). However, the fact that Jörgensen (1923) found this form to be "numerous" in the Mediterranean and always characterized by these features very strongly indicates that we are concerned with characters of specific value. The reasons given by Jörgensen (1923, p. 23) for assigning to *D. sphaerica* Stein the specimens of *D. similis* found by him hardly can be considered as valid. As the type of *D. similis* we regard the specimen represented by Jörgensen's (1923) figure 29.

The structurally closest-known relatives of *Dinophysis similis* are *D. sphaerica* and *D. ovum*. The two last species differ from the first mainly in having the

posterior main rib of the left sulcal list well developed, about as long as or somewhat longer than the fission rib of this list, and in having the posteroventral portion of this list angular, instead of rounded to rounded angular. (See also *Dinophysis sphaerica* and *Phalacroma expulsum*, the sections on comparisons.)

Synonymy: — As stated above, *Dinophysis similis* has previously been treated by Schütt (1895) and Jörgensen (1923) under the name of *D. sphaerica* Stein. *D. sphaerica* Pavillard (1916) is also identical with *D. similis*, and not with *D. sphaerica* Stein, as is plainly shown by Pavillard's (1916, p. 60) statement that his specimens of this species had the body of about the same shape as the specimen represented by Schütt's (1895) Plate 1, figure 7: 1, and that their left sulcal list "répond exactement au dessin de Schütt; son bord inférieur est convex et non concave comme dans le dessin approximatif de Stein." It should be noted in this connection that *D. sphaerica* Schütt (1895, p. 64) refers to *Phalacroma rotundatum* (Claparède and Lachmann).

Occurrence: — *Dinophysis similis* is recorded at two of the 127 stations. Of these two stations, one (4691) is on the third line of the Expedition and in the Easter Island Eddy; the other (4701) is on the fourth line and in the South Equatorial Drift, just to the north of the Easter Island Eddy. Both records refer to hauls from 300–0 fathoms.

The temperature of these two stations at the surface was 72° and 73°.

The frequency is less than 1% at both stations.

Schütt (1895) does not give any information as to the localities of his material; however, it probably was taken in the tropical and subtropical regions of the Atlantic or near Naples. Pavillard (1916) found this species to be rare in the Gulf of Lyons. Jörgensen (1916) reports it as fairly common and "widely distributed in the Western Mediterranean"; he also found it in the Bay of Cadiz and in the Guinea Current. It probably is widely distributed in tropical, subtropical, and warm-temperate seas.

Dinophysis okamurai, sp. nov.

Figure 31: 5

Dinophysis vanhöffenii Okamura, 1907, *partim*, p. 131, pl. 5, fig. 41c.

Diagnosis: — Body subovate in lateral outline, with dorsal shoulder-like constriction at girdle, with ventral margin somewhat concave between R_2 of left sulcal list and epitheca, deepest in the middle, and 1.32–1.50 times longer than deep. Anterior cingular list about as wide as transverse furrow. Left sulcal list 0.44–0.50 the length of the body; distance between R_1 and R_3 0.37–0.42 the length

of the body; R_2 is 0.15, R_3 is 0.12–0.29 the greatest depth of body; margin forms angle of 100°–110° at R_3; R_3 inclined posteriorly at 5°–25°. Length, 38.3–53.0 μ.

Eastern tropical Pacific, Japan.

Description: — This is a rather small or medium-sized species, the body of which is subovate in lateral outline, with a dorsal shoulder-like constriction at the girdle, with the ventral margin somewhat concave between the fission rib of the left sulcal list and the epitheca, and deepest in the middle. The ratio between the length and the depth of the body is 1.32–1.50: 1. The longitudinal axis is about perpendicular to the girdle.

The epitheca is about 0.37–0.38 as deep as the hypotheca, slightly convex, highest in or near the middle, and not visible above the anterior cingular list. The transverse furrow is flat or slightly concave, and about three times as wide as the greatest height of the epitheca. The posterior cingular list is about 0.10–0.11 the length of the body from the apex. The hypotheca is somewhat asymmetrical. The dorsal margin is moderately and subuniformly convex. The ventral margin is gently to moderately concave in front of the fission rib of the left sulcal list; behind this rib it is slightly convex or almost straight. The postmargin is strongly and subuniformly convex and confluent with the dorsal and ventral margins. The posterior portion of the body is decidedly deeper than the anterior.

The anterior cingular list, which is about as wide as the transverse furrow and 0.16–0.28 the greatest depth of the body, has an anterior inclination of 30°–40°. The posterior cingular list is narrower than the anterior, sometimes even very narrow as in the type specimen; it has an anterior inclination of 40°–50°. The structure of the cingular lists is unknown. The right sulcal list extends to the fission rib of the left sulcal list and is subtriangular in shape, decreasing gradually in width posteriorly. The left sulcal list is comparatively small. Its length is 0.44–0.50 the length of the body, and the distance between the anterior and posterior main ribs is 0.37–0.42 the length of the body. The anterior main rib is about 0.18, the fission rib 0.15, and the posterior main rib 0.12–0.29 the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior main rib and the fission rib and between the fission rib and the posterior main rib, the free margin of this list is straight or almost so; at the fission rib it forms an obtuse angle; at the posterior main rib it forms an angle of 100°–110°; behind the last rib it is almost straight. The main ribs of this list are straight or almost so, and not club-shaped or otherwise modified. The distance between the anterior main rib and the fission rib is 0.35–0.40 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior in-

clination of 5°–25°. We do not know whether or not this list has any structural differentiation besides the main ribs. There are no accessory lists or sails. The structure of the theca is unknown; judging by Okamura's (1907, pl. 5, fig. 41c) figure, it appears to be a fine areolation.

Megacytic stages have not been recorded.

The dimensions of the type specimen and of the specimen figured by Okamura (1907, pl. 5, fig. 41c) were measured.

Dimensions: — Length of body, 38.3–53.0 μ (type, 53.0 μ). Greatest depth of body, 25.4–40.0 μ (type, 40.0 μ).

Comparisons: — *Dinophysis okamurai* is established on a single outline drawing of a specimen in lateral view found in the material of the Expedition. The shape of the body in dorsoventral view, the structure of the cingular lists and of the theca are unknown, and our knowledge of the structure of the left sulcal list is incomplete.

When compared with the type specimen, the specimen figured by Okamura (1907, pl. 5, fig. 41c) is smaller (38.3 μ as compared with 53.0 μ) and narrower (ratio between length and depth of body, 1.50: 1 as compared with 1.32: 1); its ventral margin is more concave anteriorly, and its posterior cingular list is somewhat wider relatively. The fission rib of its left sulcal list is comparatively long, which makes the ventral margin of this list more angular at this rib than in any other known species. The difference in the shape of the ventral margin of the body may be due to the fact that Okamura (1907) made his drawing from a detached valve.

The shape of the body in lateral view and the shortness of the left sulcal list in this species are suggestive of *Dinophysis ovum* and *Phalacroma expulsum*. However, these resemblances cannot be considered as sufficient proofs of a close relationship. *Dinophysis okamurai* is easily distinguished from *D. ovum* by the characteristic sinuation of the ventral margin of its body and from *Phalacroma expulsum* by the shape of its left sulcal list.

Synonymy: — Under the name of *Dinophysis vanhöffenii* Ostenfeld, Okamura (1907) figures two specimens, one of which (his Plate 5, fig. 41c) belongs to the species described above. Later (1912) he writes *D. vanhöffenii* Okamura (1907) as a synonym of *D. ovum* Schütt.

Occurrence: — *Dinophysis okamurai* is recorded at only one (4673, the type locality) of the 127 stations, on the third line of the Expedition, in the Peruvian Current, from 300–0 fathoms, at a surface temperature of 67°. The frequency is less than 1% (one specimen).

Previously the species was found in Japanese waters by Okamura (1907).

Dinophysis fortii Pavillard

Figure 31: 7

Dinophysis fortii Pavillard, 1923a, p. 881.
Dinophysis laevis Bergh, Pouchet, 1883, p. 426, pl. 18, 19, fig. 6.
Dinophysis intermedia Pavillard, 1916, p. 58, pl. 3, fig. 4. Forti, 1923, p. 110, 112, 190, 209, fig. 119. Jörgensen, 1923, p. 19, 21, 22, 44, 45.
Dinophysis intermedia f. *pachyderma* Jörgensen, 1923, fig. 21.

Diagnosis: — Body narrowly subovate in lateral outline, with flattened ventral margin, and broadly and evenly rounded posteriorly; deepest somewhat behind the middle, and 1.44–1.56 times longer than deep; longitudinal axis deflected posteroventrally at 3°–15°. Markedly compressed bilaterally, with lateral contours almost parallel. Anterior cingular list 1.4–2.0 as wide as transverse furrow, without ribs. Left sulcal list 0.63–0.67 as long as body; distance between R_1 and R_3 0.50–0.53 the length of body; R_2 is 0.26–0.30, R_3 is 0.33–0.43 the greatest depth of body; margin forms angle of 65°–85° at R_3; R_3 inclined posteriorly at 10°–25°; besides main ribs this list has distinct reticulation. Theca finely and closely areolate. Length, 62.3–66.1 μ.

Probably widely distributed in subtropical, warm-temperate, and temperate seas.

Description: — This is a medium-sized species, narrowly subovate in lateral outline, with flattened ventral margin, broadly and evenly rounded posteriorly, and deepest somewhat behind the middle. The ratio between the length and the depth of the body is 1.48 (1.44–1.56): 1. The longitudinal axis is deflected posteroventrally at 9° (3°–15°).

The epitheca is 0.38–0.48 as deep as the hypotheca, moderately convex (Figure 31: 7) to almost flat (Jörgensen, 1923, fig. 21), not visible above the anterior cingular list, and highest in or somewhat dorsally to the center. The transverse furrow is flat, or slightly concave or convex, and its depth is 2.0–2.5 the greatest height of the epitheca. The posterior cingular list is 0.09–0.10 the length of the body from the apex. The hypotheca is somewhat asymmetrical to subsymmetrical, and more or less deflected posteroventrally (see above). Its dorsal margin (from the girdle to the antapex) is rather strongly and almost evenly convex. Its ventral margin (between the anterior and posterior main ribs of the left sulcal list) is almost straight, or slightly and evenly convex. Its postmargin is evenly subsemicircular and confluent with the dorsal and ventral margins; it does not form an angle just behind the posterior main rib of the left sulcal list. The posterior end of the body is strikingly deeper than the anterior. In dorsoventral view the body is markedly compressed bilaterally, and its lateral contours are subparallel (Jörgensen, 1923, p. 19).

The cingular lists may be subequal, but in most cases the anterior is somewhat wider than the posterior; the anterior is 1.5–2.0 as wide as the transverse furrow, and 0.20–0.23 the greatest depth of the body; both are funnel-shaped, with an anterior inclination of 30°–50°; sometimes the posterior is somewhat less, in other cases somewhat more inclined anteriorly than the anterior; both lack distinct structural differentiation. The right sulcal list ends at or just behind the fission rib of the left sulcal list; it is subtriangular and decreases gradually in width posteriorly; anteriorly it is about as wide as, or slightly wider or narrower than the transverse furrow; its ventral margin is slightly and evenly convex, or almost straight. The left sulcal list is fairly large. Its length is 0.66 (0.63–0.67) the length of the body; and the distance between the anterior and posterior main ribs is 0.52 (0.50–0.53) the length of the body. The anterior main rib is 0.25 (0.24–0.26), the fission rib 0.28 (0.26–0.30), and the posterior main rib 0.38 (0.33–0.43) the greatest depth of the body; behind the last rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list either is almost straight (Pavillard, 1916, pl. 3, fig. 4), or it is almost straight anteriorly and gently convex posteriorly (Jörgensen, 1923, fig. 21); at the posterior main rib it forms an angle of 75° (65°–85°); behind the last rib it either is nearly straight (Pavillard, 1916, pl. 3, fig. 4) or more or less concave (Jörgensen, 1923, fig. 21). The two anterior of the main ribs are of moderate strength, and straight or nearly so; the posterior, which sometimes (Jörgensen, 1923, fig. 21) is club-shaped, is almost straight (Pavillard, 1916, pl. 3, fig. 4), or more or less strikingly concave posteriorly (Jörgensen, 1923, fig. 21). The distance between the anterior main rib and the fission rib is 0.44 (0.40–0.50) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 18° (10°–25°). Besides the main ribs this list has a well-developed reticulation. There are no accessory lists or sails. The thecal wall is closely and rather finely areolate; the areoles are subequal in size.

Megacytic specimens have not been recorded.

The dimensions of one specimen found in the material of the Expedition and of the specimens figured by Pavillard (1916, pl. 3, fig. 4) and Jörgensen (1923, fig. 21) were measured.

Dimensions: — Our specimen: Length of body, 62.3 μ. Greatest depth of body, 40.0 μ. Type specimen (Pavillard, 1916, pl. 3, fig. 4): Length of body, 66.1 μ. Greatest depth of body, 45.7 μ. The specimen figured by Jörgensen (1923, fig. 21) was 63.8 μ long and 43.7 μ deep. According to a statement in the text, the specimens examined by Jörgensen (1923, p. 19) were about 64 μ long and 49 μ deep "reckoned vertically and parallel to girdle."

Variations: — This species appears to be rather variable. The most variable of its characters are as follows: the inclination of the longitudinal axis of the body, the curvature of the epitheca, the shape of the posterior portion of the left sulcal list, and the shape and structure of the posterior main rib of this list.

Comparisons: — The specimen found in the material of the Expedition and assigned to *Dinophysis fortii* shows a close agreement with the type specimen as figured by Pavillard (1916, pl. 3, fig. 4). It differs from the type mainly in being somewhat smaller and more slender.

The specimen figured by Jörgensen (1923, fig. 21) under the name of *Dinophysis intermedia* Pavillard, f. *pachyderma* has the longitudinal axis of the body rather strikingly inclined posteroventrally; the posterior portion of the left sulcal list is strikingly recurved; and the posterior main rib of this list is decidedly club-shaped and has a pronounced posterior concavity.

Dinophysis fortii is morphologically and probably also genetically intermediate between *D. ovum* Schütt and *D. schröderi*. Of these three species *D. ovum* is the shortest, most rounded, and presumably most primitive; *D. schröderi* is the longest, most elongate, and presumably most highly developed (see also *D. schröderi*, the section on comparisons).

Synonymy: — This species was established by Pavillard (1916), who described and figured it under the name of *Dinophysis intermedia*. Jörgensen (1923), who described it under the same name, once, on page 22, used the name *D. intermedium* (*lapsus pennae*). Without referring to it in the text, Jörgensen (1923, fig. 21) figured a specimen under the name of *D. intermedia* Pavillard, f. *pachyderma*. According to our opinion, this specimen is an old, thick-walled representative of the main species, and so its name has been included in our bibliographical list of *D. fortii*. Fortî (1922) gave a reproduction of Pavillard's (1916) figure of the type specimen.

Pavillard (1923a, p. 881) rejected *intermedia* as the specific name of this form and replaced it with *fortii*, on account of the fact that *Dinophysis intermedia* Pavillard (1916) was antedated by *D. intermedia* Cleve (1902b, p. 30).

Jörgensen (1923, p. 19) suggests that *Dinophysis atlantica* Ehrenberg (1854, p. 239) may be identical with this species. This question cannot be settled as yet, since Ehrenberg's (1854a) diagnosis of *D. atlantica* is too incomplete for certainty of specific identification.

Pouchet (1883, p. 426, pl. 18–19, fig. 6) figures, under the name of *Dinophysis laevis* Bergh, a specimen which very decidedly resembles *D. fortii*. Pouchet's assignment of this specimen is wrong. According to our opinion, *D. laevis* Pouchet

(1883) may be identical with *D. fortii*, but Jörgensen (1899, p. 30) refers it to *D. acuminata* Claparède and Lachmann, and Paulsen (1908, p. 15) to *D. arctica* Mereschowsky.

Jörgensen (1923, p. 19) suggests that the specimen which Cleve (1901c, p. 239) recorded from the Florida Current under the designation of *Dinophysis acuta* Ehrenberg belonged to *D. intermedia* (= *fortii*). This suggestion has not been verified as yet.

Occurrence: — *Dinophysis fortii* is recorded at only one of the 127 stations. This station (4667) is on the second line of the Expedition and in the Peruvian Current. The depth is 300–0 fathoms, the surface temperature 68°, and the frequency less than 1% (one specimen).

The type locality of this species is the Gulf of Lyons (Pavillard, 1916). Forti (1922) obtained one specimen in the Ligurian Sea, and Jörgensen (1923) found the species to be widely distributed throughout the Mediterranean. Outside the Mediterranean the species has been found by Jörgensen (1923), who reported it from the Bay of Cadiz, and "from the Florida Current (off the northern coast of Florida, temp. 23°C., 6/5 1910) and from several places, partly in mixed water, along the northern course of the Gulf Stream, far to the south of Nova Scotia, from 39° to 43° N., and 70°–40° W. (temp. 22°–18°C., salinity abt. 36.5)." *Dinophysis atlantica* Ehrenberg (1854a), which may be identical with *D. fortii*, was taken off Newfoundland. *D. laevis* Pouchet (1883), which also may be identical with *D. fortii*, was found at Concarneau, on the west coast of France.

The species probably is eupelagic and widely distributed in subtropical, warm-temperate, and temperate seas.

Dinophysis norvegica Claparède and Lachmann?

Figure 31: 8

?Dinophysis norvegica Broch, 1910a, p. 31, fig. 1: A, B.

The single specimen represented by Figure 31: 8 was taken in the Panamic Area, at Station 4638 of the Expedition. The depth was 300–0 fathoms, and the surface temperature was 75°. The length of this specimen is 44.5 μ. The similarity between this specimen and the one from Spitzbergen figured by Broch (1910a, fig. 1: A) is very striking. However, since the surface markings of the theca are not indicated in our drawing, and a certain knowledge of this character is essential for a well-founded determination of the species of the Acuta group, our assignment of this specimen should be regarded as tentative. A record of this specimen is being published mainly because of the fact that *Dinophysis*

norvegica, which supposedly is a neritic and boreoarctic species, has not been found previously in waters of tropical and subtropical character. Our specimen might have been a vagrant from polar waters.

Dinophysis schröderi Pavillard

Figure 31:6

Dinophysis schroederi Pavillard, 1909, p. 284, fig. 5; 1916, p. 58, pl. 3, fig. 5. Schiller, 1911a, p. 52; 1911b, p. 90. Schröder, 1911, p. 22, 25, 36. Forti, 1922, p. 110, 112, 190, 209, fig. 120. Jörgensen, 1923, p. 21, 45, fig. 22.

Diagnosis: — Body elongated in lateral outline, deepest somewhat behind the middle, 1.68–1.90 times longer than deep; dorsal margin fairly strongly convex; ventral margin nearly straight in front of R_3 of left sulcal list and more or less angular at R_3; narrowly rounded to subacute posteriorly; longitudinal axis deflected posteroventrally at 1°–12°. Markedly compressed bilaterally; lateral contours parallel or even slightly concave. Anterior cingular list 1.4–2.0 as wide as transverse furrow, without ribs. Left sulcal list 0.66–0.70 as long as body; distance between R_1 and R_3 0.58–0.61 the length of body; R_2 is 0.20–0.31 and R_3 is 0.33–0.50 the greatest depth of body; margin forms angle of 40°–55° at R_3; R_3 inclined posteriorly at 10°–35°; except for main ribs this list almost lacks structure. Theca finely and closely areolate. Length, 73.0–88.0 μ.

Probably widely distributed in subtropical, warm-temperate, and temperate seas.

Description: — This is a medium-sized species, the body of which is elongate in lateral outline, with well-convex dorsal margin, almost straight ventral margin, subacute antapical end, and the greatest depth somewhat behind the middle. The ratio between the length and the depth of the body is 1.79 (1.68–1.90):1. The longitudinal axis is deflected posteroventrally at 7° (1°–12°).

The epitheca is 0.43–0.46 as deep as the hypotheca, rather strongly convex (Figure 31:6) to almost flat (Jörgensen, 1923, fig. 22), not visible above the anterior cingular list, and highest in or somewhat dorsally to the center. The transverse furrow is flat or slightly concave or convex, and its width is 1.5–2.5 the greatest height of the epitheca. The posterior cingular list is 0.07–0.11 the length of the body from the apex. The hypotheca is asymmetrical and more or less deflected posteroventrally (see above). Its dorsal margin (from the girdle to the antapex) is rather strongly convex; sometimes (Figure 31:6) the convexity is almost even, sometimes (Pavillard, 1916, pl. 3, fig. 5) it is more pronounced near the middle than anteriorly and posteriorly. Its ventral margin (between the

anterior and posterior main ribs of the left sulcal list) is almost straight or but slightly convex or concave. Just behind the posterior main rib of the left sulcal list the margin forms a more or less pronounced but rounded corner, and between this corner and the antapex the margin is almost straight or slightly convex. Posteriorly the body is narrowly rounded to subacute. However, according to Jörgensen (1923, p. 21), some specimens which "undoubtedly should be referred to *D. schroederi*" had the posterior end of the body "evenly rounded"; these specimens were from the southern part of the Atlantic. In dorsoventral view the body is markedly compressed bilaterally, with the lateral contours parallel or even slightly concave (Jörgensen, 1923, p. 21).

The cingular lists may be subequal (Pavillard, 1909, fig. 5), but in most cases the posterior is somewhat narrower than the anterior; the anterior is 1.4–2.0 as wide as the transverse furrow and 0.21 (0.17–0.25) the greatest depth of the body; both are funnel-shaped, with an anterior inclination of 20°–40°; sometimes the posterior is somewhat less inclined anteriorly than the anterior; both lack distinct structural differentiation. The right sulcal list ends at or just in front of the fission rib of the left sulcal list; it is subtriangular and decreases gradually in width posteriorly; anteriorly it is about as wide as or slightly wider than the transverse furrow; its ventral margin is almost straight, gently and evenly convex, or gently convex anteriorly and slightly concave posteriorly. The left sulcal list is fairly large; its length is 0.68 (0.66–0.70) the length of the body, and the distance between the anterior and posterior main ribs is 0.60 (0.58–0.61) the length of the body. The anterior main rib is 0.22 (0.17–0.27), the fission rib 0.25 (0.20–0.31), and the posterior main rib 0.41 (0.33–0.50) the greatest depth of the body; behind the last rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list either is almost straight, or it is almost straight anteriorly and gently convex posteriorly (Pavillard, 1916, pl. 3, fig. 5), or slightly undulating, concave anteriorly and posteriorly and convex in the middle (Pavillard, 1909, fig. 5); at the posterior main rib this margin forms an angle of 48° (40°–55°); behind the last rib it either is almost straight (Figure 31: 6) or more or less strikingly concave (Jörgensen, 1923, fig. 22). The main ribs of this list are of moderate strength; the two anterior are straight or almost so; the posterior, which may be club-shaped (Jörgensen, 1923, fig. 22), is almost straight (Figure 31: 6), or more or less strikingly concave posteriorly. The distance between the anterior main rib and the fission rib is 0.42 (0.40–0.50) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 20° (10°–35°). Except for the main ribs this list is

without structure, or it has a faint reticulation near the posterior main rib. There are no accessory lists or sails. The thecal wall is closely and rather finely areolate.

Megacytic specimens have not been recorded.

The dimensions of one specimen found in the material of the Expedition and of the specimens figured by Pavillard (1909, fig. 5; 1916, pl. 3, fig. 5) and Jörgensen (1923, fig. 22) were measured.

Dimensions: — Our specimen: Length of body, 73.0 μ. Greatest depth of body, 38.5 μ. Type specimen (Pavillard, 1909, fig. 5): Length of body, 88.0 μ. Greatest depth of body, 52.2 μ. The specimen figured by Pavillard (1916, pl. 3, fig. 5) was 81.5 μ long and 46.7 μ deep; according to Pavillard (1916, p. 58) this species has a length of 80 μ or more, and a depth of 45–50 μ. The specimen figured by Jörgensen (1923, fig. 22) was 83.2 μ long and 45.4 μ deep.

Variations: — Judging by the available figures, this species appears to be relatively constant. However, the specimens examined by Jörgensen (1923) seem to have been rather variable, since this investigator points out that he at times found it difficult to distinguish with certainty between this species and *Dinophysis acuta* Ehrenberg (Jörgensen). The most variable characters are: the size of the body, the inclination of the longitudinal axis of the body, the curvature of the epitheca, the shape of the dorsal margin of the body, and the shape and structure of the posterior main rib of the left sulcal list.

Comparisons: — The specimen found in the material of the Expedition and assigned to *Dinophysis schröderi* agrees rather closely with the specimens from the Mediterranean figured by Pavillard (1909, 1916). It differs from these specimens mainly in being somewhat smaller (73.0 μ as compared with 81.6–88.0 μ) and more slender.

The specimen from the Mediterranean figured by Jörgensen (1923) also agrees closely with Pavillard's (1909, 1916) specimens. It is noteworthy because of its flat epitheca and the somewhat club-shaped posterior main rib of its left sulcal list.

Dinophysis schröderi is structurally very closely related to *D. acuta* Ehrenberg (Jörgensen). Indeed, we should have been inclined to regard these two forms as belonging to the same species, if it were not for the fact that *D. schröderi* was established by such a careful investigator as Pavillard, who, moreover, reported *D. acuta* from the same locality as *D. schröderi*. According to Pavillard's (1916) data, these two forms differ mainly in the size of the body and in the shape of the posterior portion of the body. Jörgensen (1923, p. 21) seems to be somewhat in doubt as to the status of *D. schröderi* as an independent species; he writes as

follows: *D. schröderi* "seems therefore to be a true Mediterranean species (*or form*)," and it "is at times hard to distinguish with certainty" from *D. acuta*. According to Jörgensen (1923), *D. schröderi* differs from *D. acuta* in the following respects: — (*1*) it is somewhat more elongated; (*2*) its dorsal margin is somewhat more evenly convex; (*3*) the posterior portion of its body, as a rule, is slightly more rounded; (*4*) it is markedly compressed in dorsoventral view with the lateral contours of the body parallel to each other or even slightly concave, while in *D. acuta* the body in dorsoventral view "is generally narrowly elliptical, with convex lateral contours"; (*5*) its anterior cingular list is slightly higher relatively, and narrower at the base; and (*6*) its left sulcal list is almost without reticulation.

Dinophysis schröderi is also structurally close to *D. fortii*. It differs from this species mainly in the subacute posterior end of its body, in the angularity of the ventral margin of its body at the posterior main rib of the left sulcal list, and in the very slight development of the reticulation of its left sulcal list (see also *D. fortii*, the section on comparisons).

Another close relative of *Dinophysis schröderi* probably is *D. norvegica*. However, the latter species, which is easily recognized by its heavy surface markings, is too insufficiently known for a detailed comparison.

Synonymy: — This species was established by Pavillard (1909, p. 284, fig. 5), who described and figured it under the name of *Dinophysis schroederi*. Later it was described and figured by Pavillard (1916) and by Jörgensen (1923) under the same name. Forti (1922) gave a reproduction of Pavillard's (1916) figure of this species.

Occurrence: — *Dinophysis schröderi* was obtained at only one of the 127 stations. This station (4574) is on the first line of the Expedition and in the California Current. The sample was taken at the surface. The surface temperature was 69°, and the frequency less than 1% (one specimen).

The species was first recorded by Pavillard (1909, 1916) from the Gulf of Lyons, which thus is the type locality. Later it was reported from the Ligurian Sea by Forti (1922) and from the Adriatic by Schiller (1911a, 1911b) and Schröder (1911). Jörgensen (1923) found it to be widely distributed throughout the Mediterranean. Outside the Mediterranean it has been recorded only by Jörgensen (1923), who found it in the Bay of Cadiz and at "several places in the southern Atlantic, partly near and west of the southernmost part of Africa (German South-Pole Expedition, 1/7–1/8 1903), partly east of South America ('Fram' 1911)."

Of the writers who have contributed to our knowledge of the distribution of

this species, Schiller and Schröder do not give any descriptions or figures by means of which their determinations may be checked.

This is a eupelagic species widely distributed but rare in subtropical, warm-temperate, and temperate seas.

2. Hastata Group. Fourteen species are assigned to this group. Of these the following have been found to occur in the Eastern Pacific: — *Dinophysis hastata, D. uracantha, D. urceolus, D. monacantha, D. trapezium, D. swezyi, D. collaris, D. schütti, D. nias, D. jörgenseni,* and *D. triacantha.*

Dinophysis hastata Stein

Figure 32, 34

Dinophysis hastata Stein, 1883, pl. 19, fig. 12. Hensen, 1887, p. 77, tab. 13, 15; 1895, p. 190; 1911, p. 165, tab. 15. Möbius, 1887, p. 121. Ostenfeld, 1898b, p. 42, tab. 5; 1899, tab. 5, 8; 1900, p. 56, tab. 2, 5–7; 1906, p. 18; 1909, p. 22; 1913a, p. 309; 1916b, p. 13. Murray & Whitting, 1899, p. 331, tab. 1–3, 6. Jörgensen, 1899, p. 32, lxxii; 1912, p. 11, 16; 1923 (*partim?*), p. 31–33, 44. Lemmermann, 1899a, p. 319, 372; 1901a, p. 374; 1902a, p. 263; 1905a, p. 36. Ostenfeld & Schmidt, 1901, p. 169. Cleve, 1901a, p. 15; 1901c, p. 239; 1902b, p. 29; 1903b, p. 343. Entz, 1902b, p. 94; 1905, p. 111. Ostenfeld & Paulsen, 1904, p. 164, 171. Zacharias, 1906, p. 530. Karsten, 1907, p. 234. Paulsen, 1907, p. 5; 1908, p. 12, 13, fig. 9; 1912, p. 289. Nathansohn, 1908, p. 604; 1909, p. 46; 1910, p. 61, fig. 29: 12. Gräf, 1909, p. 143, 151, 155, 159, 171, 173, 179, 182, 184, 188, 190, 192. Pavillard, 1909, p. 283, 284; 1915a, p. 2; 1916, p. 47, 53, 60; 1923a, p. 879, 880, fig. 2A. Okamura, 1912, p. 19, 33, fig. 73–75. Mangin, 1912, p. 33, tab. 2. Forti & Issel, 1923, p. 3, 4, fig.; 1924, p. 7.

Phalacroma hastatum Pavillard, 1909, p. 283, fig. 4; 1916, p. 53; 1923a, p. 879, 880. Schiller, 1911a, p. 52; 1912, p. 27. Schröder, 1911, p. 17, 25, 37. Forti, 1922, p. 104, fig. 108. Lebour, 1925, p. 83, fig. 21c.

Dinophysis hastata var. or form. *phalacromides* Jörgensen, 1923, p. 31, fig. 41 (*nomen rejectum*).

Dinophysis hastata var. or form. *uracanthides* Jörgensen, 1923, p. 31, 32, 33, fig. 40 (*nomen rejectum*).

Dinophysis uracantha var. *mediterranea* Jörgensen, 1923, p. 32, fig. 43.

Dinophysis hastata var. *parvula* Lindemann, 1923, p. 219, fig. 6.

Diagnosis: — Body subobovate, subovate, or subellipsoidal in lateral outline; rounded, subtruncate, or truncate anteriorly; subacute, or narrowly to broadly rounded posteriorly; deepest somewhat in front of to somewhat behind the middle; length: depth, 1.10–1.60: 1; longitudinal axis deflected posteroventrally at 0°–15°. In dorsal view narrowly obovate, about 2.5 times longer than wide. Cingular lists sometimes but slightly inclined anteriorly; epitheca sometimes visible above anterior cingular list; anterior cingular list 1.5–2.5 times wider than transverse furrow; posterior sometimes ribbed. Left sulcal list 0.48–0.77 the length of body; distance between R_1 and R_3 0.37–0.58 the length of body; R_2 is 0.11–0.29, R_3 is 0.25–0.74 the depth of body; margin forms angle of 20°–90° at R_3; R_3 inclined posteriorly at 15°–55°; sometimes with reticulation and accessory ribs. With triangular to spine-like posterior sail, usually somewhat ventrally to midline, and inclined ventrally at 0°–40°; its length 0.19–0.61 the depth of body and 1.0–4.0 its basal width; with or without central rib or reticulation, sometimes

with marginal ribs; separated from left sulcal list. Theca usually finely and closely areolate. Length, 42.5–90.0 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas, seldom in colder waters.

Description: — This is a medium-sized to small species, the body of which is very variable in shape. It is subobovate, subovate, or subellipsoidal in lateral outline; rounded, subtruncate, or truncate anteriorly; subacute, or narrowly to broadly rounded posteriorly; and deepest somewhat in front of to somewhat behind the middle. The ratio between the length and the depth of the body is 1.10–1.60: 1; in our specimens this ratio is 1.27 (1.17–1.38): 1; in Stein's (1883, pl. 19, fig. 12) figure of the type specimen it is about 1.60: 1; in Okamura's (1912, fig. 73–75) specimens, 1.10–1.18: 1; and in Pavillard's (1909, fig. 4A), Jörgensen's (1923, fig. 40, 41), and Lindemann's (1923, fig. 6) specimens, 1.14–1.27: 1. The longitudinal axis either is perpendicular to the transverse furrow, as in the type specimen, or it is deflected posteroventrally at an angle of 1°–15°; in our specimens this deflection is 6° (0°–11°); in Pavillard's (1909) specimen, which is extreme in this respect, it is 15°.

The epitheca is very variable in depth and shape; it is 0.67 (0.54–0.86) as deep as the hypotheca, usually gently convex, but sometimes rather strongly convex (Figure 32: 14) or more or less flat (Figure 32: 9; Figure 33: 2), highest in the center or near the dorsal side (Figure 32: 9; Figure 33: 1, 3), and sometimes visible above the anterior cingular list. The transverse furrow is flat or slightly convex, and about as wide as or somewhat wider or narrower than the greatest height of the epitheca. The posterior cingular list is 0.18 (0.12–0.24) the length of the body from the apex. The hypotheca sometimes is symmetrical, *e.g.*, in the type specimen and in the specimens represented by our Figure 32: 12, 13, 16; but usually it has a more or less pronounced posteroventral inclination (see above). The dorsal margin (from the girdle to the antapex) usually is subuniformly and gently to moderately convex; sometimes it is more or less flattened anteriorly (Figure 32: 2) or posteriorly (Figure 32: 8), or both anteriorly and posteriorly (Figure 32: 10, 11). The ventral margin (from the girdle to the antapex) usually is more or less flattened posteriorly, or it is subuniformly and gently to moderately convex; sometimes (Figure 32: 9) it forms a broadly rounded corner at or near the posterior main rib of the left sulcal list. The posterior portion of the body is subacute, or narrowly to broadly rounded; in most specimens it is strikingly narrower than the anterior portion, but sometimes it is of about the same depth (Figure 32: 7) or even deeper (Figure 32: 13). In dorsoventral view (Pavil-

lard, 1909, fig. 4B) the body is narrowly obovate, about 2.5 times longer than wide, and its side contours are evenly convex.

The cingular lists are subequal or the posterior is somewhat narrower than

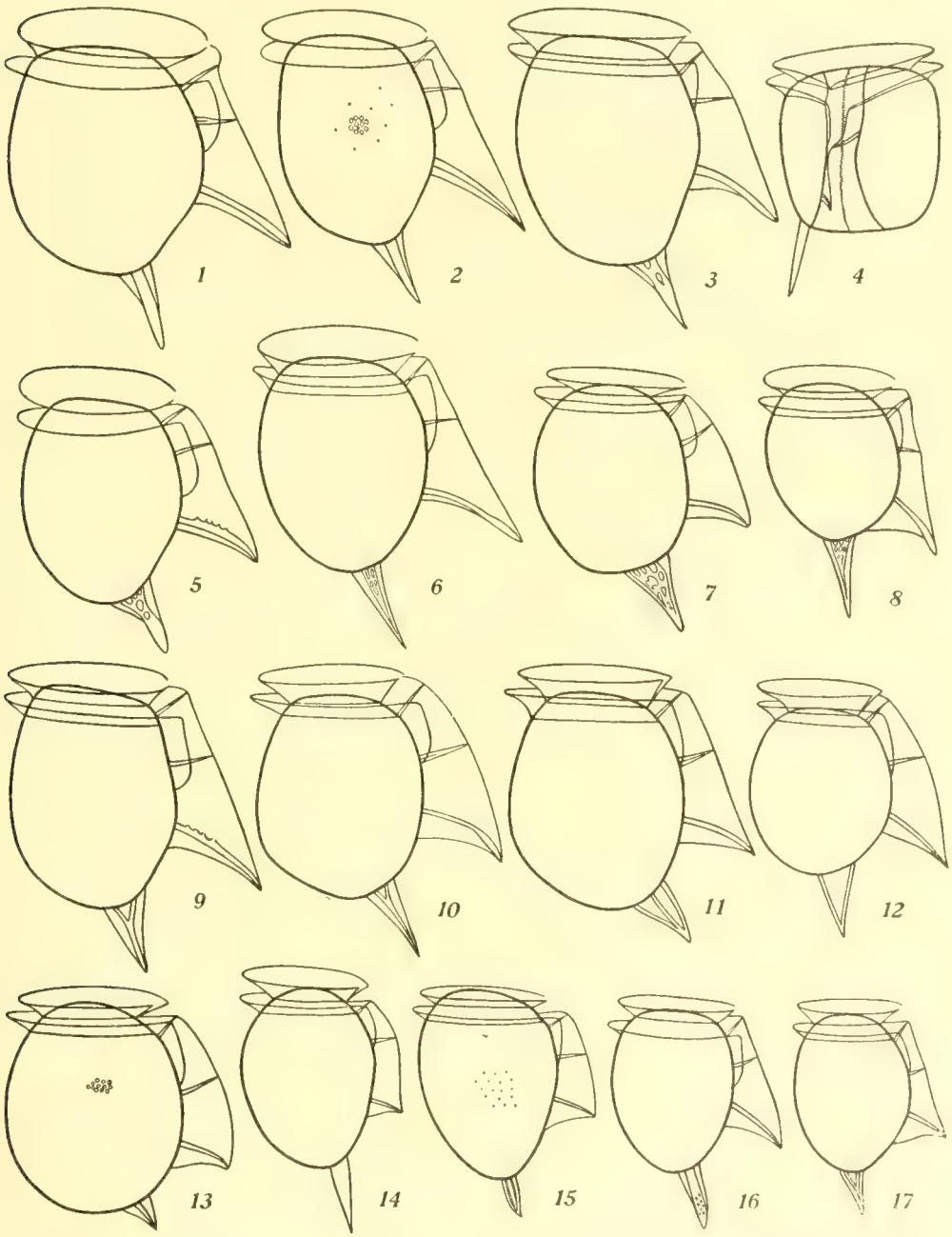

FIGURE 32.— *Dinophysis hastata* Stein, all, except 4, seen in right lateral view; 4, in ventral view; structure of thecal wall indicated in 2, 13, and 15 only; 4 and 14 from the same specimen. × 430. 1, 5, 6, 9, 10, from Station 4737 (300–0, or 100–0 fathoms); 2, from Station 4732 (300–0 fathoms); 3, from Station 4734 (300–0 fathoms); 4, 14, from Station 4724 (300–0 fathoms); 7, from Station 4722 (300–0 fathoms); 8, 13, from Station 4730 (300–0 fathoms); 11, 12, from Station 4740 (300–0 fathoms); 15, 16, 17, from Station 4711 (300–0 fathoms).

the anterior. In the type specimen (Stein, 1883, pl. 19, fig. 12) and in the specimen figured by Jörgensen (1923, fig. 43) under the name of *Dinophysis uracantha* var. *mediterranea,* the posterior list is very narrow, about 0.30–0.40 the width of the anterior (see the section on comparisons). The anterior cingular list is 1.5–2.5 times wider than the transverse furrow and 0.20 (0.13–0.27) the greatest depth of the body. In most specimens both these lists are more or less funnel-shaped, being inclined anteriorly at 20°–50°; sometimes, however, the posterior or even both of them (Jörgensen, 1923, fig. 41; Pavillard, 1909, fig. 4A) may be subhorizontal. The anterior one has, on each valve, about 15–25 usually simple, straight, and almost equidistant ribs; sometimes these ribs ramify and anastomose into an indistinct and incomplete reticulum (Jörgensen, 1923). The posterior cingular list may have the same structure as the anterior (Pavillard, 1909, fig. 4A), but usually it lacks structural differentiations. The right sulcal list sometimes ends at the fission rib of the left sulcal list, but usually it extends somewhat beyond this rib; in exceptional cases (Jörgensen, 1923, fig. 41) it extends as far as to the posterior main rib of the left sulcal list; it either is subtriangular, decreasing gradually in width posteriorly, or it is of subuniform width throughout the greater part of its length and rounded posteriorly (Figure 32: 9); anteriorly it is about as wide as the transverse furrow, sometimes somewhat narrower. The left sulcal list is of moderate size or rather large, and usually strikingly wider posteriorly than anteriorly. Its length is 0.58 (0.48–0.77) the length of the body, and the distance between the anterior and posterior ribs is 0.48 (0.37–0.58) the length of the body. The anterior main rib is 0.19 (0.13–0.25), the fission rib 0.22 (0.11–0.29), and the posterior main rib 0.52 (0.25–0.74) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is almost straight (Figure 32: 6, 11), evenly and gently to moderately convex (Figure 32: 11, 13), or slightly irregular (Pavillard, 1909, fig. 4A; Jörgensen, 1923, fig. 41). At the posterior main rib this margin forms an angle of 45° (20°–90°). Behind this rib the margin may be almost straight (Figure 32: 11), but usually it is gently to moderately concave. The main ribs of this list are of moderate strength; the anterior two are straight or almost so; the posterior, which sometimes (Figure 32: 6, 10) is club-shaped, may be straight, but in most specimens it is gently to moderately concave posteriorly. The distance between the anterior main rib and the fission rib is 0.42 (0.30–0.55) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 30° (15°–55°). In some specimens the entire left sulcal list has a fairly well-developed reticula-

tion; in other specimens it has numerous fine ribs and imperfect reticulation; sometimes there is no structural differentiation except the three main ribs. On the right valve there is an acute, triangular to spine-like posterior sail, which is situated either on or generally somewhat ventrally to the midline, and is inclined ventrally at 0°–40°; in our specimens this sail has a ventral inclination of 22° (7°–40°), in Stein's (1883) specimen it was parallel to the longitudinal axis of the body. The left sulcal list usually ends at a distance from the posterior sail equaling about 0.30 the greatest depth of the body; in extreme cases the corresponding figure may be as high as 0.45, or the left sulcal list may extend almost to the posterior sail (Figure 32: 8). The size of the posterior sail is somewhat variable, probably due to the fact that in each binary fission one of the daughter schizonts has to form this structure anew. When fully developed, its length is 0.46 (0.19–0.61) the greatest depth of the body; *i.e.*, its average length is slightly less than that of the posterior main rib of the left sulcal list. It is 2.2 (1.0–4.0) times longer than it is wide at the base. In most cases it is straight or almost so; its margins are almost straight, or gently convex, concave, or sigmoid; and the angle at its tip is 22° (10°–40°). In most of our specimens this sail is supported by a central rib, which may be quite or nearly solid (Figure 32: 1, 2), more or less broken up into an irregular reticulum (Figure 32: 3, 5, 7), or bifurcate at the base (Figure 32: 9, 10). In one of our specimens (Figure 32: 11) this sail had a marginal rib besides a central rib, in another (Figure 32: 12) only a marginal rib (see also the section on comparisons). No parasagittal lists are developed.

In most specimens (Figure 32: 2) the thecal wall is finely and closely areolate and has scattered pores; some specimens (Figure 33: 1) are characterized by rather large areoles, others (Figure 33: 2) are reticulate. In northern waters the living cell, according to Jörgensen (1923, p. 31), is "of a light rose, without chromatophores, or hyaline."

Megacytic stages were seen by Pavillard (1916, p. 47) and by ourselves (Figure 32: 4).

The dimensions of nineteen of our specimens and of the specimens figured by Stein (1883), Pavillard (1909), Okamura (1912), Jörgensen (1923), and Lindemann (1923) were measured.

Dimensions: — Our specimens: Length of body, 50.2–80.6 μ (average, 67.2 μ). Greatest depth of body, 37.7–63.8 μ (average, 53.3 μ). The size of the type specimen (Stein, 1883, pl. 19, fig. 12) is unknown. Judging by Stein's (1883) information about the magnification of his figures, given in an introductory remark to the explanation of the plates, the length of this specimen was somewhere between

71.5 μ and 110.0 μ. A specimen found by Jörgensen (1899, p. 32) on the west coast of Norway was 73 μ long and 53 μ deep. The specimens recorded by Pavillard (1909, fig. 4A) under the name of *Phalacroma hastatum* were 85–90 μ long and 35–40 μ deep. The three specimens figured by Okamura (1912, fig. 73–75) were 59.5–77.5 μ long and 50.6–70.3 μ deep. The specimens represented by Jörgensen's (1923) figures 40 and 41 were 58.7 μ long and 47.5 μ deep, and 78.0 μ long and 61.3 μ deep, respectively; the specimen figured by Jörgensen (1923, fig. 43) under the name of *Dinophysis uracantha* var. *mediterranea* was 42.5 μ long and 38.0 μ deep. Lindemann's (1923) specimen was 60 μ long.

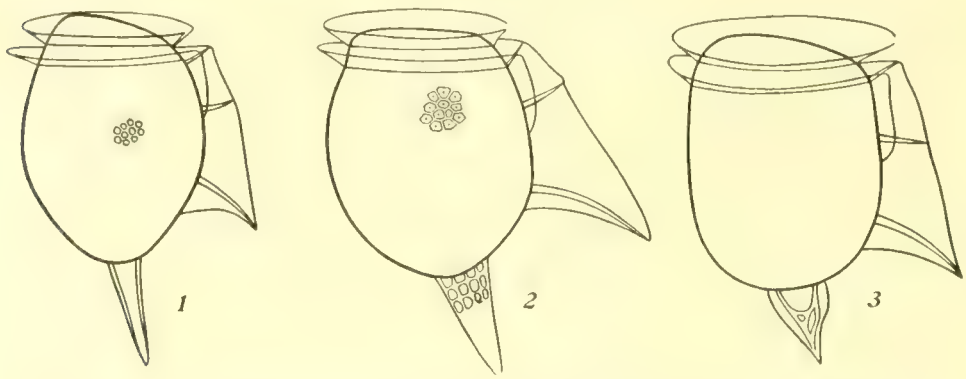

FIGURE 33.—*Dinophysis hastata* Stein, right lateral view of three aberrant specimens; structure of thecal wall indicated in 1 and 2. Specimen represented by 2 had left sulcal list and posterior sail heavily reticulated, but its posterior sail had no central rib. × 430. 1, from Station 4711 (300–0 fathoms); 2, from Station 4730 (300–0 fathoms); 3, from Station 4732 (300–0 fathoms).

Variations: — The variability of *Dinophysis hastata*, as conceived in the present paper and by Jörgensen (1923), is amazing, and, according to our opinion, there can be but little doubt that future investigators, with adequate material at their disposal, will find it necessary and feasible to divide this species into two or more systematic units. The principles which we have been forced to apply in our treatment of this species completely upset those used in almost all the other species of the genera Dinophysis and Phalacroma. Indeed, some of our specimens of this species have the habitus characteristic of Dinophysis, while others look like rather typical representatives of Phalacroma. Jörgensen (1923, p. 31) writes that this species in the Mediterranean at times varies "to an extraordinary degree."

The following characters are the most variable: — the size of the body, the inclination of the longitudinal axis of the body, the shape and the relative depth of the epitheca, the shape of the hypotheca, the inclination of the cingular lists, the width and the shape of the left sulcal list, the shape and relative size of the right sulcal list, and the size, shape, structure, and position of the posterior sail.

Comparisons: — The type specimen, as figured by Stein (1883, pl. 19, fig. 12), has an oblong, subovoidal, and symmetrical body, subtruncate anteriorly and subacute posteriorly; its anterior cingular list is wide and funnel-shaped, and its posterior cingular list is very narrow; its posterior sail is located on the very midline, directed posteriorly, and furnished with a simple, strong, central rib. Specimens of the same habitus as the type specimen appear not to have been found by later investigators. For instance, Okamura (1912) emphasizes that in his specimens the body was "shorter and more roundish" than in the type specimen, and he found the posterior sail to be without central rib or its central portion "is partly thickened like a spine." Pavillard (1916, p. 60), too, found the body to be shorter and more rounded than in Stein's (1883) figure of the type specimen; he also remarks that in his specimens the posterior sail was displaced ventrally and that the presence of a central rib in this sail "paraît très douteuse." Hensen (1895, p. 190) observed that his specimens of this species were "schief." It is, of course, not excluded that Stein (1883) made mistakes in his representation of some of the structures of the type specimen. However, the striking variability of this species makes it appear possible that this author has correctly figured a specimen of an unusual habitus. A glance at our figures will show that we have found specimens of this species (Figure 32: 16, 17) almost as elongated as in the figure of the type. As to the position and structure of the posterior sail, Jörgensen (1923, p. 31) writes as follows: "Terminal spine displaced toward the ventral side, and directed obliquely ventrally, rarely almost in the middle and pointing straight down, often with distinct median rib and more or less broad sail lists, or quite or nearly solid throughout, with narrow sail lists or none." With regard to the width of the posterior cingular list of the type, it should be mentioned that this list is very narrow in *Dinophysis uracantha* var. *mediterranea* Jörgensen (1923, p. 43), a form which probably is referable to *D. hastata* (see below, the section on synonymy).

As previously indicated, none of the specimens found in the material of the Expedition and assigned to *Dinophysis hastata* agrees exactly with the type specimen of this species, as figured by Stein (1883, pl. 19, fig. 12). Moreover, only a few of our specimens (Figure 32: 16) show a comparatively close resemblance to the type.

The specimens represented by Figure 32: 1, 2, 3, 5, 6, 9, 10, may be considered as typical of *Dinophysis hastata*, as found by us in the tropical and subtropical regions of the eastern Pacific. This form may be characterized briefly in the following way. The body is somewhat asymmetrical, with posteroventrally inclined

longitudinal axis, subovoidal, subtruncate anteriorly, and subacute to narrowly rounded posteriorly. The posterior sail is located somewhat ventrally to the midline, directed posteroventrally, and furnished with a central rib, which either is quite or nearly solid throughout or more or less broken up into an irregular reticulum.

On the other hand, the specimens represented by Figure 32: 4, 7, 8, 11–17, and by Figure 33 should be regarded as unusual. A detailed discussion of each of these figures would lead too far; the mentioning of a few outstanding facts must suffice. Figure 32: 16, as previously mentioned, approaches the type specimen as figured by Stein (1883). Figure 32: 12 resembles Jörgensen's (1923, fig. 40) figure of *Dinophysis hastata* f. *uracanthides*, and approaches *D. uracantha* in having the posterior sail bordered with marginal ribs; this specimen would have been assigned to *D. uracantha*, if its posterior sail had not been displaced ventrally. Figure 33: 2 approaches Jörgensen's (1923, fig. 41) figure of *D. hastata* f. *phalacromides*. We would have separated the three specimens represented by Figure 33, from *D. hastata*, were it not for the following statement by Jörgensen (1923, p. 31): "I have not been able with certainty to distinguish *Phalacroma hastatum* Pavill. from *Dinophysis hastata*, not even as a separate variety, though it is often rather characteristic." Since our material is not sufficient for a well-founded solution of this problem, we have considered it advisable to accept temporarily Jörgensen's (1923) decision (see Pavillard, 1923a, p. 879, 880).

Jörgensen (1923, p. 31) states that the specimens of this species, found on the west coast of Norway and in the Black Sea, are relatively small, with narrow left sulcal list without posterior main rib, and with small posterior sail. In none of the fully developed specimens of this species, found by us in the material of the Expedition and in a collection from Alaska, did the left sulcal list lack the posterior main rib.

Dinophysis hastata is structurally closely related to *D. uracantha*. The ranges of variation of these two species, as conceived in the present paper, even may overlap (see, for instance, Figure 32: 12). When typical, according to our conception of the species, *D. hastata* differs from the typical *D. uracantha* in being somewhat larger, in having the body more elongated and somewhat deflected posteroventrally, and in having the posterior sail situated somewhat ventrally to the midline.

Dinophysis monacantha, *D. pusilla*, and *D. alata* are presumably also rather close relatives of *D. hastata*. These relationships are indicated by the presence of a posterior sail and by the relatively simple structure of the left sulcal list. The

typical *D. hastata* differs from *D. monacantha* mainly in lacking a parasagittal list, in having the longitudinal axis of the body deflected posteroventrally instead of posterodorsally, and in having the posterior sail with a central and not with a marginal rib. From *D. pusilla* it differs strikingly in its larger size and in its more elongated body. *D. alata* is characterized by the wide parasagittal list along the dorsal margin of the body. See also *D. monacantha*, the section on comparisons.

Synonymy: — The species was established by Stein (1883, pl. 19, fig. 12), who figured it under the name of *Dinophysis hastata*. Later it was described by Paulsen (1908, p. 13) and figured by Okamura (1912, fig. 73–75) and Forti and Issel (1923) under the same name. Paulsen (1908), who bases his description on Stein's (1883) figure of the type specimen, gives a reproduction of this figure. Other reproductions of Stein's (1883) figure are to be found in Nathansohn (1910, fig. 29: 12) and Lebour (1925, fig. 21e).

For reasons mentioned in the section on comparisons, the name of *Phalacroma hastatum* Pavillard (1909) has been included in our bibliographical list of *Dinophysis hastata*. However, we wish to emphasize that this should be regarded as a tentative measure, and that we consider it possible that *Phalacroma hastatum* is specifically distinct. It should be pointed out in this connection that Schiller (1911a, 1912) and Schröder (1911), who recorded *Phalacroma hastatum* from the Adriatic Sea, as well as Forti (1922), who found it in the Ligurian Sea, did not mention *Dinophysis hastata* as occurring in their collections. Forti (1922) gives a reproduction of Pavillard's (1909) figure of *Phalacroma hastatum* (see also Pavillard, 1923a, p. 879). It should be noted that if this form is specifically distinct, then its name must be changed, since *P. hastatum* is preoccupied. This name was first used as a *nomen nudum* by Hensen (1895, p. 190; see also Hensen, 1911, p. 166, 167).

Jörgensen (1923, p. 31) writes that he had tried to distinguish between two varieties of *Dinophysis hastata*, viz., var. *uracanthides* and var. *phalacromides*, the latter "answering to *Phalacroma hastatum* Pavill.," "but this again cannot, as far as my experience goes, be maintained with certainty." *Dinophysis uracantha* Stein var. *mediterranea* Jörgensen (1923) should be assigned to *D. hastata* in spite of its small size, since the longitudinal axis of its body is deflected posteroventrally, and since its posterior sail is situated ventrally to the antapex and is furnished with a central rib and not with marginal ribs.

Lindemann's (1923, fig. 6) figure of *Dinophysis hastata* var. *parvula* from the Bosporus corroborates Jörgensen's (1923, p. 31) statement that the specimens of

this species found by him in the Black Sea were relatively small, with small left sulcal list and small posterior sail.

Occurrence: — *Dinophysis hastata* is recorded at forty-eight of the 127 stations. There are 10, 9, 9, 7, 9, and 4 stations on the six lines of the Expedition. Of these forty-eight stations, three (4571, 4580, 4583) are in the California Current; six (4587, 4588, 4590, 4594, 4596, 4605) are in the Mexican Current; four (4613, 4634, 4637, 4638) are in the Panamic Area; eight (4650, 4651, 4659, 4664, 4665, 4666, 4675, 4676) are in the Peruvian Current; five (4689, 4691, 4695, 4697, 4699) are in the Easter Island Eddy; twenty (4679, 4680, 4681, 4683, 4687, 4701, 4705, 4707, 4711, 4717, 4721, 4722, 4724, 4730, 4732, 4734, 4737, 4739, 4740, 4741) are in the South Equatorial Drift; one (4742) is in the South Equatorial Current; and one (4542) is in the Equatorial Counter Current. There are eight records from the surface (Stations 4583, 4588, 4596, 4666, 4676, 4680, 4741, 4542); at two of these stations (4583, 4676) the species was taken in hauls from 300–0 fathoms as well as at the surface; at one station (4666) it was taken in a haul from 800–0 fathoms as well as at the surface; at the remaining five stations it is recorded from surface catches only. At one station (4737) the species is recorded from 100–0 fathoms and 300–0 fathoms, and at one station (4681) from 800–0 fathoms and 300–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The species is also recorded from surface waters in Acapulco Harbor, off the Mexican Current. This station is not included in the 127 stations mentioned above.

The temperature range of these forty-eight stations at the surface was 66°–85°; the average was 75.3°. At the eight stations in the surface catches of which this species was found, the surface temperature ranged from 67° to 84°; the average was 76.7°.

At two of the surface stations (4542, 4666) a frequency of 1% was found; in the remaining cases frequencies of less than 1% are recorded. For the catches from 100, 300, or 800 fathoms to the surface the records of frequency are as follows: 2% at one station (4689), 1% at ten stations (4571, 4580, 4587, 4634, 4681, 4724, 4734, 4737, 4740, 4742), and less than 1% at the remaining stations.

In addition it may be mentioned that we have found this species also in plankton from Yes Bay, Alaska.

Stein (1883) recorded this species "aus dem Atlantischen Meer und der Südsee." It was mentioned as occurring in the Cattegat by Ostenfeld (1906,

1916b) and Paulsen (1912); and in the Skager Rak by Paulsen (1907), Jörgensen (1912), and Ostenfeld (1913a). (It has not been found in the Baltic. Lemmermann's, 1902a, p. 263, statement that Möbius, 1887, recorded it from the western part of the Baltic is erroneous.) It was found on the west coast of Norway by Jörgensen (1899, 1912); in the North Sea, by Ostenfeld (1906, 1909) and by Paulsen (1912). Ostenfeld (1898b, 1899, 1900) reported it from twelve localities in the northern part of the Atlantic, between lat. 59° 36′ N.–63° 57′ N. and long. 2° 28′ W.–28° 45′ W. Hensen (1887) and Möbius (1887) found it west of Scot-

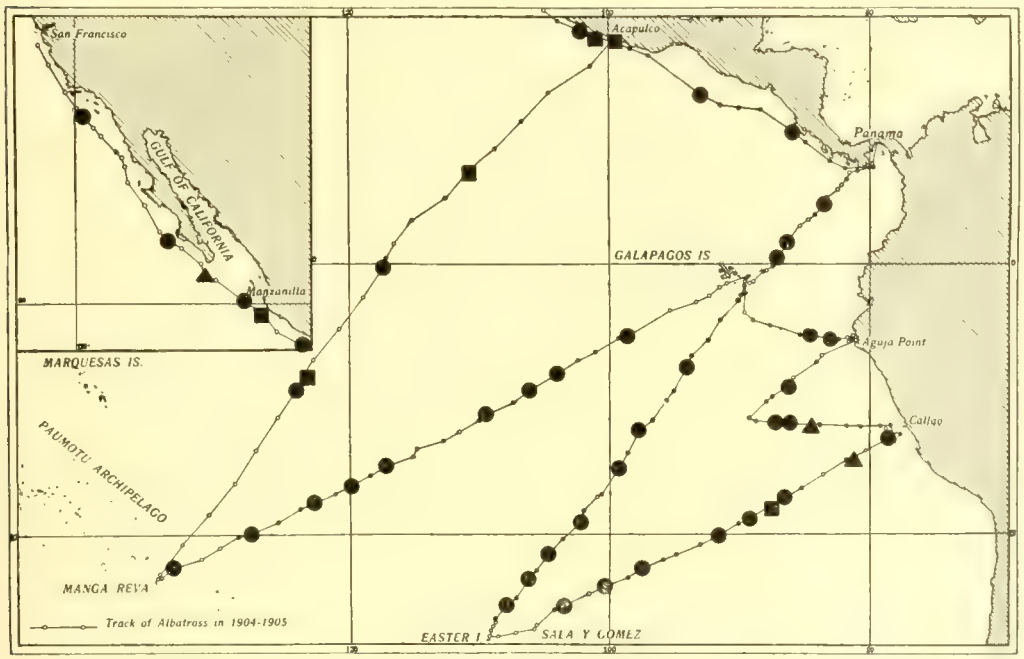

FIGURE 34.— Occurrence of *Dinophysis hastata* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

land, at about lat. 57° N. and long. 10°–11° W., and Ostenfeld and Paulsen (1904) at lat. 59° 41′ N., long. 22° 27′ W. Other papers in which this species is mentioned as occurring in the northern part of the Atlantic are Ostenfeld (1906) and Paulsen (1912). Mangin (1912) found it in the English Channel; Jörgensen (1923), on the southwest coast of Portugal and in the Bay of Cadiz; Murray and Whitting (1899), at six stations in the Atlantic, between lat. 45° 38′ N.–18° 20′ N. and long. 13° 53′ W.–52° 40′ W.; Cleve (1901c), at twelve localities in the Atlantic, between lat. 62° N.–19° S., and long. 1° W.–66° W.; Cleve (1903b), at lat. 37° N., long. 8° W.; Cleve (1902b), at lat. 24° S., long. 4° E.; Gräf (1909), at lat. 4° 37′ N., long. 9° 52′ W., lat. 17° 22′ S., long. 0° 13′ E., and lat. 31° 12′ S., long. 16° 1′ E.;

Hensen (1911), in the Gulf Stream, Florida Current, Sargasso Sea, Canary Current, North Equatorial Current, Guinea Current, South Equatorial Current, and on the coast of Brazil. In the Mediterranean this species has been found by several investigators, viz.: in the Gulf of Lyons, by Pavillard (1909, 1916); off Monaco, by Nathansohn (1908, 1909); in the Ligurian Sea, by Forti (1922); near Naples, by Zacharias (1906); in the Adriatic Sea, by Entz (1902b, 1905), Schröder (1911), Schiller (1911a, 1912), and Forti and Issel (1923); and at a rather great number of localities in various parts of the Mediterranean, by Jörgensen (1923). Lindemann (1923) reported it from the Bosporus; and Jörgensen (1923) from the Marmora Sea, Bosporus, and the Black Sea. In the Red Sea it was found by Cleve (1903b); in the Gulf of Aden, by Ostenfeld and Schmidt (1901), and by Cleve (1903b); in the Arabian Sea, at lat. 9° N., long. 59° E., by Cleve (1901a); in the Indian Ocean, at lat. 2° S., long. 91° E., by Cleve (1901a), at lat. 34° 13′ S., long. 80° 30′ E., by Karsten (1907), and at the Suvadiva Atoll, at Rodriguez Island, and on the west coast of Madagascar by Gräf (1909); in the Antarctic Ocean, south of Africa, at lat. 42° 55′ S., long. 22° 53′ E., by Gräf (1909); in the East Indies, near Sumatra, Celebes, Amboina, and on the north coast of New Guinea, by Gräf (1909); in Japanese waters, by Okamura (1912); and in the Peruvian Current by Lemmermann (1899a).

Karsten (1907) reported the species as taken with a closing net between 80 and 60 meters. Most of the remaining records refer to surface hauls.

According to the investigators who have contributed to our knowledge of the distribution of this species, it occurs in waters of the following temperatures and salinities. Ostenfeld (1898b): — temperature, 51.8°; salinity, 35.25. Ostenfeld (1899): — temperature: range, 44.6°–52.7°; mean of four observations, 48.8°. Salinity: range, 35.37–35.50; mean of four observations, 35.41. Ostenfeld (1900): — temperature: range, 45.0°–55.4°; mean of seven observations, 52.4°. Salinity: range, 35.00–35.34; mean of seven observations, 35.18. Murray and Whitting (1899): — temperature: range, 61°–79°; mean of six observations, 71.9°. Cleve (1901a): — temperature, 82.3°; salinity, 32.13. Cleve (1901c): — temperature: range, 44.6°–77.2°; mean of eighteen observations, 63.7°. Salinity: range, 33.93–37.36; mean of eighteen observations, 35.71. Cleve (1902b): — temperature, 71.6°; salinity, 35.95. Cleve (1903b): — temperature, 60.3°–84.7°; salinity, 36.44–40.70 (four samples). Ostenfeld and Paulsen (1904): — temperature, 52.2°. Gräf (1909): — temperature, 82.8°–84.1° (two samples). Salinity: range 33.78–36.22; mean of eleven observations, 34.79.

Of the authors who have contributed to our knowledge of the distribution of

this species, only Stein (1883), Pavillard (1916), Okamura (1912), Forti (1922), Jörgensen (1923), Forti and Issel (1923), and Lindemann (1923) give descriptions or drawings by means of which their determinations of this species may be checked (see the section on synonymy).

Dinophysis hastata is eupelagic and occurs in tropical, subtropical, and warm-temperate regions of all seas. It has been found in the northern part of the Atlantic, in the North Sea, Norwegian Sea, Skager Rak, and Cattegat, but it is probably a warm-water form and not endogenetic in these waters. The specimens recorded probably were stragglers of southern origin, carried to the north by the Gulf Stream (see Paulsen, 1912, p. 289). It is thermophilous but eurythermal and, as far as known, stenohaline. According to our records, it is almost uniformly distributed throughout the area investigated by the Expedition and has its optimum habitat in deeper waters, within the levels of photosynthesis.

Dinophysis uracantha Stein

Figure 35, 36

Dinophysis uracantha Stein, 1883, pl. 20, fig. 22, 23. Hensen, 1895, p. 190; 1911, p. 165, tab. 15. *non* Schütt, 1895, p. 16, 17, pl. 2, fig. 9. Lemmermann, 1899a, p. 373; 1901a, p. 375; 1905a, p. 36. Murray & Whitting, 1899, p. 331, tab. 1–6, 8, 9. Schröder, 1900a, p. 35; 1906a, p. 326, 329. Ostenfeld & Schmidt, 1901, p. 171. Cleve, 1903b, p. 344. Zacharias, 1906, p. 557. Kofoid, 1907a, p. 196; 1910a, p. 184. Karsten, 1907, p. 234, 237, 247. Pavillard, 1916, p. 60; 1923a, p. 879, 880, fig. 2B. Jörgensen, 1923, p. 31, 33, 34, fig. 42. Forti & Issel, 1924, p. 6, 7. Lebour, 1925, p. 83, fig. 20g.

non *Dinophysis uracantha* var. *mediterranea* Jörgensen, 1923, p. 32, fig. 43.

Diagnosis: — Body subcircular to subovate in lateral outline, seldom truncate anteriorly; deepest somewhat in front of to somewhat behind the middle; length: depth, 0.98–1.14: 1; longitudinal axis deflected posterodorsally at 0°–13°. Anterior cingular list 1.5–2.5 times wider than transverse furrow; epitheca seldom visible above this list. Left sulcal list 0.60–0.75 the length of body; distance between R_1 and R_3 0.50–0.57 the length of body; R_2 is 0.13–0.30, R_3 is 0.50–0.88 the greatest depth of body; margin forms angle of 20°–40° at R_3; R_3 inclined posteriorly at 20°–55°; sometimes with secondary ribs and reticulation. With triangular or claw-like posterior sail located somewhat dorsally to midline; its length is 0.45–0.88 the greatest depth of body and 1.5–3.0 its basal width; with marginal ribs but without central rib; separated from left sulcal list. Theca finely and closely areolate. Length, 37.5–63.5 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas, seldom in colder waters.

Description: — This is a small or medium-sized species of rather variable

shape. The body is subcircular to subovate in lateral outline, seldom truncate anteriorly, and deepest somewhat in front of, to somewhat behind, the middle. The ratio between the length and the depth of the body is 1.07 (0.98–1.14): 1. The longitudinal axis either is perpendicular to the transverse furrow, as in the specimen represented by Stein's (1883) Plate 20, figure 23, or it is deflected posterodorsally at 8° (1°–13°).

The epitheca is variable in depth and shape; it is 0.59 (0.40–0.69) as deep as the hypotheca, usually gently convex, but sometimes rather strongly convex (Figure 35: 2) or flat (Figure 35: 3), highest in or near the center, and seldom visible above the anterior cingular list. The transverse furrow is flat to slightly convex, and about as wide as or more or less decidedly wider than the greatest height of the epitheca. The posterior cingular list is 0.17 (0.09–0.20) the length of the body from the apex. The hypotheca sometimes is symmetrical, *e.g.*, in the specimens represented by Figure 35: 3 and by Stein's (1883) Plate 20, figure 23, but usually it has a more or less pronounced posterodorsal inclination. The dorsal margin (from the girdle to the antapex) sometimes is subuniformly and moderately to gently convex, sometimes (Figure 35: 4) flattened anteriorly, and sometimes (Figure 35: 1) somewhat more strongly convex anteriorly than posteriorly. The ventral margin (from the girdle to the antapex) sometimes, as in the type specimen and in Figure 35: 3, is subuniformly and moderately convex, but usually it is more or less flattened posteriorly. The posterior portion of the body is broadly rounded, but seldom (Figure 35: 2) strikingly deeper than the anterior.

The cingular lists are subequal or the posterior is slightly narrower than the anterior. In the two specimens figured by Stein (1883, pl. 20, fig. 22, 23) the posterior list is very narrow and only about 0.30–0.50 as wide as the anterior; this is probably due to an imperfect observation, since Stein (1883) made this list very narrow in almost all his figures of species of Dinophysis. The anterior of these lists is 1.5–2.5 times wider than the transverse furrow and 0.27 (0.20–0.40) the greatest depth of the body. In most specimens both these lists are funnel-shaped, being inclined anteriorly at 20°–50°; however, the posterior, which sometimes is somewhat less inclined than the anterior, may be subhorizontal (Jörgensen, 1923, fig. 42). The anterior has, on each valve, 10–20 simple, straight, and almost equidistant ribs, some of which may be incomplete; the posterior appears always to lack structure. The right sulcal list extends to or slightly beyond the fission rib of the left sulcal list, and is subtriangular, decreasing gradually in width posteriorly, or (Figure 35: 7) of subuniform width throughout the greater part of its length and rounded posteriorly; anteriorly it is about as wide as the

transverse furrow. The left sulcal list is comparatively large and usually strikingly wider posteriorly than anteriorly. Its length is 0.68 (0.60–0.75) the length of the body, and the distance between the anterior and posterior main ribs is 0.53 (0.50–0.57) the length of the body. The anterior main rib is 0.21 (0.15–0.24), the fission rib 0.22 (0.13–0.30), and the posterior main rib 0.67 (0.50–0.88) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is nearly straight, as in the type specimen and in our Figure 35: 5, or it is gently sigmoid or somewhat irregular; when sigmoid, it may be convex anteriorly and concave posteriorly (Figure 35: 6), or *vice versa* (Figure 35: 2, 3); when irregular, it may be straight anteriorly and concave posteriorly (Figure 35: 4), or *vice versa* (Figure 35: 7). At the posterior main rib this margin forms an angle of 28° (20°–40°). Behind this rib the margin usually is gently or moderately concave, but sometimes it is gently or moderately sigmoid. The main ribs of this list are of moderate strength; the two anterior are straight or almost so; the posterior, which in exceptional cases is club-shaped, may be straight, but in most specimens it is gently or moderately concave posteriorly. The distance between the anterior main rib and the fission rib is 0.38 (0.33–0.45) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 37° (20°–55°). Besides the three main ribs this list has either a more or less developed reticulum of anastomosing, almost parallel transverse ribs, or a varying number of almost parallel, or more or less irregular transverse ribs, not connected by anastomoses. On the right valve there is an acute, triangular or claw-like posterior sail, which is situated on or generally somewhat dorsally to the midline and directed posteriorly or slightly ventrally. The left sulcal list ends at a distance from the posterior sail equaling 0.38 (0.29–0.50) the greatest depth of the body. When the posterior sail is fully developed, its length is 0.60 (0.45–0.88) the greatest depth of the body, *i.e.*, its average length is slightly less than that of the posterior main rib of the left sulcal list; and it is 2.1 (1.5–3.0) times longer than it is wide at the base. Sometimes both its margins are almost straight; but generally its dorsal margin is convex and its ventral concave, or both of them are gently sigmoid (Figure 35: 6); the angle at its tip is 18° (10°–25°). It is supported by marginal ribs and lacks a central rib. No parasagittal lists are developed.

The thecal wall is finely and closely areolate; the size of the areoles is somewhat variable. The structure varies with age; in old, thick-walled specimens it is very distinct (Jörgensen, 1923, p. 32).

Megacytic stages have not been recorded.

The dimensions of nine of our specimens and of the specimens figured by Stein (1883) and Jörgensen (1923) were measured.

Dimensions: — Our specimens: Length of body, 37.5–63.5 μ (average, 50.8 μ). Greatest depth of body, 33.1–55.4 μ (average, 47.7 μ). The size of the type specimen is unknown. Judging by Stein's (1883) information about the magnification of his figures, given in an introductory note to the explanations of the plates, the length of this specimen was somewhere between 40.0 μ and 61.3 μ. The specimen figured by Jörgensen (1923, fig. 42) was 56.3 μ long and 50.0 μ deep.

Variations: — *Dinophysis uracantha*, as conceived in the present paper, is rather strikingly variable, and future investigations probably will prove it neces-

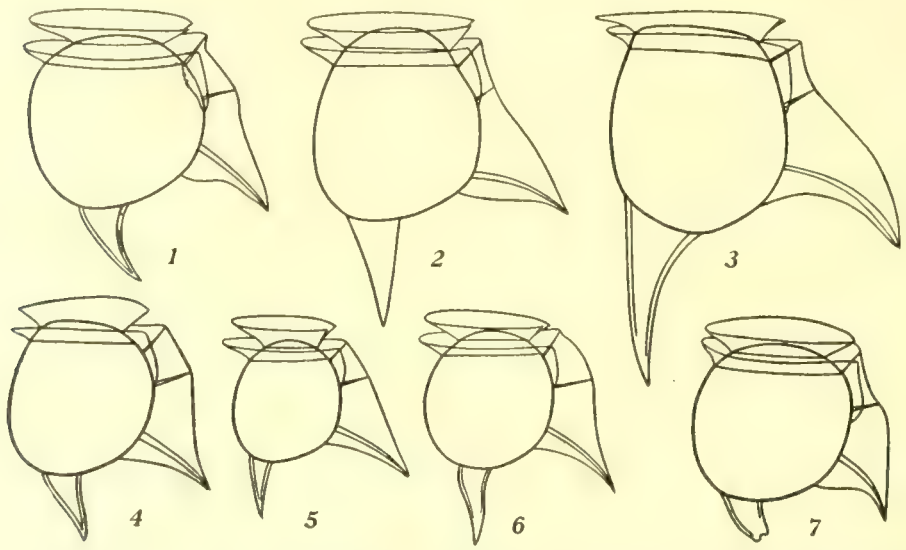

FIGURE 35.— *Dinophysis uracantha* Stein, right lateral view. 1, 4–7, typical; 2, 3, atypical. In 2 the marginal ribs of the posterior sail may have been overlooked. × 430. 1, from Station 4724 (300–0 fathoms); 2, 3, from Station 4732 (300–0 fathoms); 4, 5, 7, from Station 4722 (300–0 fathoms); 6, from Station 4711 (300–0 fathoms).

sary and possible to split this species into two or more systematic units. Our material is unfortunately insufficient for a well-founded solution of this question.

The following characters are the most variable: — the size of the body, the shape and the relative depth of the epitheca, the shape of the hypotheca, the shape and the relative width of the left sulcal list, and the shape and size of the posterior sail.

Comparisons: — Stein (1883, pl. 20, fig. 22, 23) figures two specimens of fairly different habitus under the name of *Dinophysis uracantha*. Of these specimens the one represented by his Plate 20, figure 22, should be regarded as the

type (Jörgensen, 1923, p. 32) and may be characterized briefly in the following manner: the body is subcircular in lateral view, and its longitudinal axis is slightly deflected posterodorsally; the anterior cingular list is very wide, with narrow base, funnel-shaped, and ribbed; the posterior cingular list is very narrow, inclined anteriorly, and without ribs; the posterior main rib of the left sulcal list has a pronounced posterior concavity, and the posteroventral portion of this list is strikingly recurved; the posterior sail is placed somewhat dorsally to the antapex and is supported by marginal ribs and not by a central rib; the theca has very fine areolation. The specimen represented by Stein's (1883) Plate 20, figure 23, differs from the type mainly in the following respects: the body is more elongated and decidedly deeper posteriorly than anteriorly, and its longitudinal axis is perpendicular to the girdle; the base of the anterior cingular list is wider; the posterior main rib of the left sulcal list has but a slight posterior concavity, and the posteroventral portion of this list is not strikingly recurved; the posterior sail is situated at the very antapex; the areolation of the thecal wall is somewhat coarser. Both these specimens belong to *D. uracantha* as conceived in the present paper.

Most of the specimens found in the material of the Expedition and assigned to *Dinophysis uracantha* (Figure 35: 1, 4–7) show a striking resemblance to the type; they differ mainly in the following respects: the posterior cingular list is about as wide as the anterior, the posterior main rib of the left sulcal list has but a slight posterior concavity, and the posteroventral portion of this list is not strikingly recurved. In the two last characters our specimens resemble the specimen represented by Stein's (1883) Plate 20, figure 23. The specimens represented by Figure 35: 2, 3, one of which is subovate with strongly rounded epitheca, the other subovate and strikingly truncate anteriorly, should be regarded as unusual in our material and may belong to two hitherto undescribed species, closely related to *D. uracantha*. In the specimen represented by Figure 35: 2 the marginal ribs of the posterior sail may have been overlooked.

The specimen figured by Jörgensen (1923, fig. 42) under the name of *Dinophysis uracantha* undoubtedly is correctly determined. It differs from the type mainly in the following respects: the body is less regularly subcircular, its dorsal margin being decidedly flatter than the ventral; the base of the anterior cingular list, or in other words the epitheca, is somewhat deeper; the posterior cingular list is wider. The difference in the width of the posterior cingular list may be apparent, since in Stein's (1883) iconography almost all drawings of species of Dinophysis are characterized by the extreme narrowness of this list.

The structurally closest-known relative of *Dinophysis uracantha* is *D. urceolus*, from which it is easily recognized by its more regularly shaped body (see the latter species, the section on comparisons). Next to *D. urceolus*, *D. hastata* appears to be most closely related to *D. uracantha* (see *D. hastata*, the section on comparisons). According to Jörgensen (1923, p. 33), *D. pusilla* may be a degenerate form of *D. uracantha*. The former species resembles the latter in its small size and in the subcircular shape of its body; on the other hand, the posteroventral position of its posterior sail is suggestive of a closer relationship to *D. hastata* (see also *D. monacantha*, the section on comparisons).

Synonymy: — This species was established by Stein (1883, pl. 20, fig. 22, 23), who figured it under the name of *Dinophysis uracantha*. Later it was described and figured under the same name by Jörgensen (1923, p. 32, fig. 42) and Pavillard (1923a, fig. 2B). Lebour (1923, fig. 20g) published a reproduction of Jörgensen's (1923) figure.

The specimens referred to *Dinophysis uracantha* by Schütt (1895, pl. 2, fig. 9: 1–5) were assigned to a new species, *D. schütti*, by Murray and Whitting (1899, p. 331). The specimen represented by Jörgensen's (1923) figure 42 is, in our opinion, a fairly typical *D. uracantha*. *D. uracantha* var. *mediterranea* Jörgensen (1923, fig. 43), on the other hand, probably represents *D. hastata*, since its body is fairly elongated and somewhat deflected posteroventrally, and since its posterior sail is located ventrally to the antapex and is supported by a central rib and not by marginal ribs. The specimen figured by Jörgensen (1923, fig. 40) under the name of *D. hastata* f. *uracanthides* and the one represented by our Figure 32: 12 occupy an intermediate position between *D. hastata* and *D. uracantha*, and their allocation to the former species should be regarded as tentative. The elongation of the body of these specimens and the posteroventral position of the posterior sail are suggestive of *D. hastata*, while the fact that the posterior sail is supported by marginal ribs and not by a central rib indicates a close relationship to *D. uracantha*. Furthermore, the longitudinal axis of the body is about perpendicular to the girdle, while in typical *D. hastata* and *D. uracantha* it is inclined posteroventrally and posterodorsally, respectively.

Jörgensen (1923, p. 33) writes: "The species *Dinophysis uracantha* was first recorded from the Mediterranean by Schröder, 1900 (from Naples, he does not mention the far more frequent form *D. hastata*, so that his note perhaps applies to the larger and similar *D. hastata* var. *uracanthides* . . .)." This suggestion, of course, is without foundation, since Schröder (1900a) recorded neither *D. uracantha* nor *D. hastata* from Naples. *D. uracantha* is mentioned only once by

Schröder (1900a, p. 35), and then as an example of a warm-water species of Dinophysis.

Occurrence: — *Dinophysis uracantha* is recorded at twenty-nine of the 127 stations. There are 4, 6, 3, 5, 10, and 1 stations on the six lines of the Expedition. Of these twenty-nine stations, four (4588, 4590, 4592, 4605) are in the Mexican Current; two (4637, 4638) are in the Panamic Area; five (4647, 4648, 4659, 4671, 4676) are in the Peruvian Current; three (4691, 4697, 4699) are in the Easter Island Eddy; and fifteen (4679, 4701, 4705, 4711, 4717, 4719, 4721, 4722, 4724,

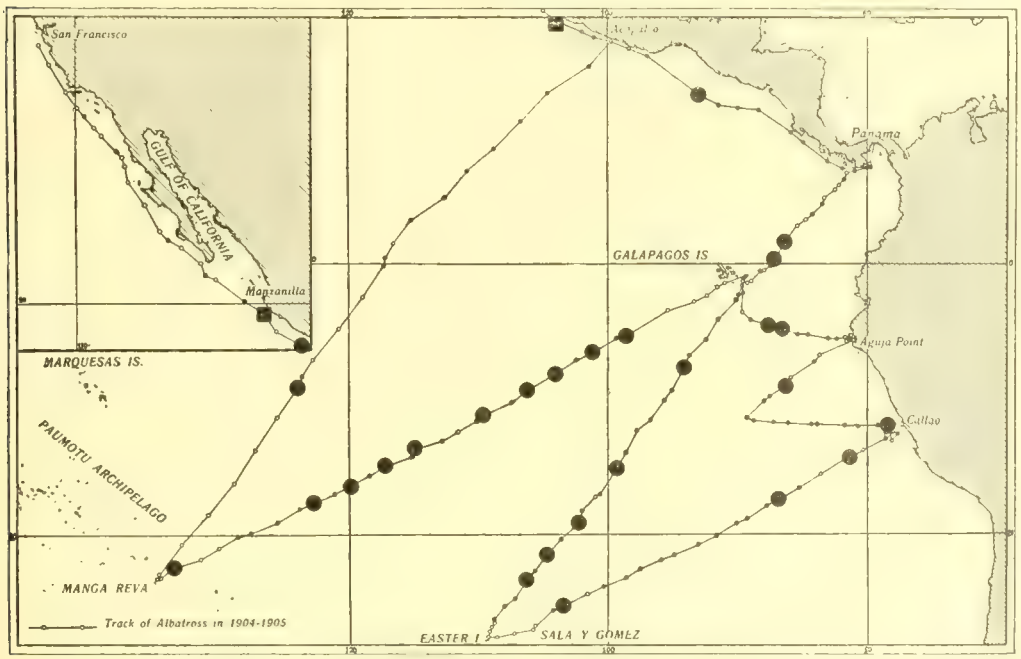

FIGURE 36.— Occurrence of *Dinophysis uracantha* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

4728, 4730, 4732, 4734, 4739, 4740) are in the South Equatorial Drift. There are two records from the surface (Stations 4588 [Salpa], 4592); at both these stations the species was taken in surface catches only. At one station (4647) the species was found only in a catch from 800–0 fathoms; and at one station (4724) in a catch from 300–0 fathoms as well as in one from 800–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these twenty-nine stations at the surface was 66°–85°; the average was 75.7°. At the two surface stations the surface temperature was 82° and 84°, respectively.

At eight stations (4590, 4592, 4638, 4648, 4671, 4679, 4722, 4740) the frequency is 1%; at the remaining ones it is less.

The specimens figured by Stein (1883) were "aus der Südsee." Murray and Whitting (1899) recorded this species from a great number of localities in the Atlantic, between lat. 18° N. and lat. 43° N., and in the Caribbean Sea; their northernmost localities are situated in the Gulf Stream. Zacharias (1906) found it in the Atlantic, at lat. 12° N., long. 28° W. Hensen (1911) recorded it at several stations in different regions of the Atlantic, viz., in the Irminger Sea, Gulf Stream, Florida Current, Sargasso Sea, Canary Current, North Equatorial Current, Guinea Current, South Equatorial Current, and off the coast of Brazil. Jörgensen (1923) reported it from the west coast of Norway (at Bergen), the Bay of Biscay, the west coast of Portugal, the Bay of Cadiz, the Gulf of Guinea, and the southern Atlantic. In the Mediterranean this species has been found by the following investigators, viz.: at lat. 36° N., long. 5° W., by Cleve (1903b); in the Gulf of Lyons, by Pavillard (1916); and at several stations in different regions of this sea, by Jörgensen (1923). In the Arabian Sea it has been recorded by Ostenfeld and Schmidt (1901) and by Schröder (1906a); in the Indian Ocean by Schröder (1906a) and by Karsten (1907); Karsten found it at three localities between lat. 10° S. and lat. 34° S.

Karsten (1907) reported this species as taken with a closing net between 80 and 60 meters. Most of the remaining records refer to surface hauls.

According to the investigators who have contributed to our knowledge of the distribution of this species, it occurs in waters of the following temperatures and salinities. Murray and Whitting (1899): — temperature, 54°–84°. Cleve (1903b): — temperature, 66°; salinity, 36.45.

Of the authors mentioned in this section only Stein (1883) and Jörgensen (1923) give descriptions or figures by means of which their determinations of this species may be checked. With regard to Jörgensen's (1923) determinations, see the section on synonymy.

This is a eupelagic species, widely distributed in tropical, subtropical, and warm-temperate seas. It has been found as far to the north as in the Irminger Sea and on the west coast of Norway (at Bergen), but is probably a warm-water species, and the specimens found in these relatively cold regions were presumably of southern origin, carried to the north by the Gulf Stream. This supposition is borne out by the fact that this species has never been recorded by the International Council for the Investigation of the Sea. According to our records, it is almost uniformly distributed throughout the area investigated by the Expedition and has its optimum habitat in deeper waters, within the levels of photosynthesis. Its absence from the California Current may be worth emphasis.

Dinophysis urceolus, sp. nov.

Figure 37: 1

Diagnosis: — Body rounded subtrapeziform to pitcher-shaped in lateral outline, deepest in or just behind the middle, and 1.13 times longer than deep; longitudinal axis deflected posterodorsally at 10°. Cingular lists inclined anteriorly at only 10°–20°, subequal, about twice as wide as transverse furrow. Left sulcal list 0.73 the length of body; distance between R_1 and R_3 0.58 the length of body; R_2 is 0.21, R_3 is 0.51, the greatest depth of body; margin forms angle of 25°–30° at R_3; posteroventral portion of list recurved; R_3 inclined posteriorly at 50°–55°. With triangular posterior sail somewhat dorsally to midline; its length 0.44 the greatest depth of body and 1.6 the basal width; with marginal ribs but without central rib. Distance between posterior sail and left sulcal list 0.50 the greatest depth of body. Length, 48.5 μ.

Eastern tropical Pacific.

Description: — This is a small species, the body of which is rounded subtrapeziform to pitcher-shaped in lateral outline, and deepest in or just behind the middle. The ratio between the length and the depth of the body is 1.13: 1. The longitudinal axis is deflected posterodorsally at about 10°.

The epitheca is about 0.53 as deep as the hypotheca, gently concave, highest dorsally, and not visible above the anterior cingular list. The transverse furrow is gently concave and somewhat wider than the greatest height of the epitheca. The posterior cingular list is 0.14 the length of the body from the apex. The hypotheca is asymmetrical. The dorsal margin (from the girdle to the posterior sail) is subuniformly and moderately convex. The ventral margin (from the girdle to the posterior end of the left sulcal list) is subuniformly and gently convex. The postmargin is but slightly convex, inclined dorsoposteriorly at an angle of 15°–20° to a plane parallel to the girdle.

The cingular lists are subequal, about twice as wide as the transverse furrow and 0.25 the greatest depth of the body, and have an anterior inclination of only 10°–20°; their structure is unknown. The right sulcal list extends slightly beyond the fission rib of the left sulcal list, is subtriangular, decreasing gradually in width posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is about 0.73 the length of the body; and the distance between the anterior and posterior main ribs is about 0.58 the length of body. The anterior main rib is about 0.21, the fission rib 0.21, and the posterior main rib 0.51 the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in

width. Between the anterior and posterior main ribs the free margin of this list is gently undulating, slightly convex anteriorly and posteriorly and slightly concave in the middle. At the posterior main rib this margin forms an angle of about 25°–30°; behind this rib it is moderately concave. The posteroventral portion of this list is recurved. The main ribs are of moderate strength and not club-shaped or otherwise modified; the anterior two are straight, and the posterior has a moderate posterior concavity. The distance between the anterior main rib and the fission rib is about 0.33 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 50°–55°. We do not know whether or not this list has any structural differentiation besides the main ribs. On the right valve there is an acute, triangular posterior sail, which is situated somewhat dorsally to the midline and directed posteriorly and slightly

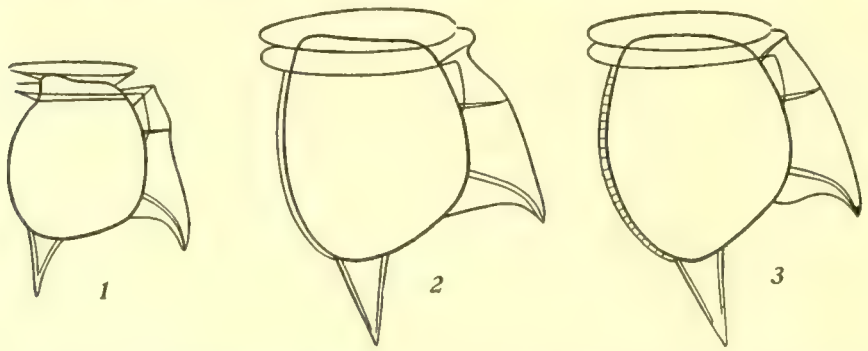

FIGURE 37.— 1, *Dinophysis urceolus*, sp. nov., right lateral view of type specimen. × 430. Station 4681 (300–0 fathoms). 2, 3, *Dinophysis monacantha*, sp. nov., right lateral view. 2, from type specimen. × 430. 2, from Station 4730 (300–0 fathoms); 3, from Station 4691 (300–0 fathoms).

dorsally. The left sulcal list ends at a distance about 0.50 the greatest depth of the body from this sail. When the posterior sail is fully developed, its length is about 0.44 the greatest depth of the body; *i.e.*, it is somewhat shorter than the posterior main rib of the left sulcal list; and it is about 1.6 times longer than it is wide at the base. Its margins are almost straight, and the angle at the tip is about 25°–30°. It is supported by marginal ribs and lacks a central rib. No parasagittal lists are developed.

Megacytic stages have not been recorded.

The dimensions of the type specimen only were measured.

Dimensions: — Length of body, 48.5 μ. Greatest depth of body, 43.0 μ.

Comparisons: — *Dinophysis urceolus* is established on a single outline drawing of a specimen in lateral view found in the material of the Expedition. The shape of the body in dorsoventral view, the structure of the cingular lists and of

the theca are unknown, and our knowledge of the structure of the left sulcal list is incomplete.

The species forms structurally a connecting link between *Dinophysis uracantha* and *D. collaris*. It resembles the former species in the small size of the body, in the posterodorsal inclination of the longitudinal axis of the body, in the shape of the left sulcal list, and in the size, structure, and position of the posterior sail. Furthermore, it approaches this species in the anterior inclination of the cingular lists. It recalls *D. collaris* very strikingly in the pitcher-like shape of the body in lateral view. It is easily distinguished from *D. uracantha* by the peculiar pitcher-like shape of the body in lateral view and from *D. collaris* in having only one posterior sail.

Dinophysis monacantha resembles *D. urceolus* in the development of the sulcal lists and of the posterior sail, and in the shape of the ventral and posterior margins of the hypotheca. The latter species is readily distinguished from the former by the smaller size of the body, by the sigmoid shape of the dorsal margin of the body, by the absence of parasagittal lists, and by the fact that the posterior sail is situated somewhat nearer to the dorsal side of the body and is inclined posterodorsally instead of posteroventrally.

Occurrence: — *Dinophysis urceolus* is recorded at only one (4681, the type locality) of the 127 stations, on the third line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, at a surface temperature of 68°. The frequency is less than 1% (one specimen).

Dinophysis monacantha, sp. nov.

Figure 37: 2, 3

Diagnosis: — Body roundèd subtrapeziform in lateral outline, deepest in or just behind the middle, and 1.19–1.22 times longer than deep; longitudinal axis perpendicular to girdle or deflected posterodorsally at 1°–3°. Cingular lists subhorizontal, subequal, 2.0–2.5 times wider than transverse furrow. Left sulcal list 0.64–0.69 the length of body; distance between R_1 and R_3 0.50–0.51 the length of body; R_2 is 0.24–0.29, R_3 is 0.45–0.50 the greatest depth of body; margin forms angle of 30° at R_3; posteroventral portion of list recurved; R_3 inclined posteriorly at 30°–40°. With triangular posterior sail located on midline or but slightly displaced dorsally or ventrally; its length is 0.45–0.52 the greatest depth of body and 1.6–2.0 its basal width; with marginal ribs but without central rib. Distance between posterior sail and left sulcal list 0.35–0.37 the greatest depth of body. Along dorsal margin a narrow parasagittal list of subuniform width, extending

from posterior cingular list to posterior sail; its average width about half the width of transverse furrow. Length, 68.2–69.7 μ.

Eastern tropical Pacific.

Description: — This is a medium-sized species, the body of which is subtrapeziform in lateral outline, deepest in or just behind the middle. The ratio between the length and the depth of the body is 1.19–1.22: 1. The longitudinal axis is either perpendicular to the girdle or deflected posterodorsally at about 1°–3°.

The epitheca is 0.64–0.72 as deep as the hypotheca, gently convex, flat or even slightly concave, highest in the middle or dorsally, and visible above the anterior cingular list. The transverse furrow is flat or gently convex, and somewhat wider than the greatest height of the epitheca. The posterior cingular list is 0.13–0.16 the length of the body from the apex. The hypotheca is asymmetrical. The dorsal margin (from the girdle to the posterior sail) is subuniformly and gently to moderately convex. The ventral margin (from the girdle to the posterior end of the left sulcal list) is subuniformly and moderately convex. The postmargin is gently convex or flattened, inclined dorsoposteriorly, forming an angle of 25°–30° to a plane parallel to the girdle, confluent with the ventral margin, and, in some specimens, forms with the dorsal margin a distinct but well-rounded corner.

The cingular lists are subhorizontal and subequal, and 2.0–2.5 times wider than the transverse furrow; their structure is unknown. The right sulcal list extends to or slightly beyond the fission rib of the left sulcal list, and is subtriangular, decreasing gradually in width posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is 0.64–0.69 the length of the body, and the distance between the anterior and posterior main ribs is about 0.50–0.51 the length of body. The anterior main rib is 0.20–0.21, the fission rib 0.26 (0.24–0.29), and the posterior main rib 0.47 (0.45–0.50) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is gently and evenly convex, or it is somewhat concave anteriorly; at the posterior main rib it forms an angle of about 30°, and behind this rib it is gently concave or sigmoid. The posteroventral portion of this list is somewhat recurved. The main ribs are of moderate strength, and not club-shaped or otherwise modified; the two anterior are straight or almost so, and the posterior one has a moderate posterior concavity. The distance between the anterior main rib and the fission rib is 0.38–0.40 the distance between the anterior and posterior main ribs. The posterior main

rib has a posterior inclination of 30°–40°. We do not know whether or not this list has any structural differentiation besides the main ribs. On the right valve there is an acute, triangular posterior sail, which is located on the midline or but slightly displaced dorsally or ventrally and directed somewhat posteroventrally. The left sulcal list ends at a distance from this sail equaling about 0.35–0.37 the greatest depth of the body. When the posterior sail is fully developed, its length is 0.45–0.52 the greatest depth of the body; *i.e.*, it has about the same length as the posterior main rib of the left sulcal list; and it is 1.6–2.0 times longer than its width at the base. Its margins are almost straight, and the angle at the tip is 25°–30°. It is supported by marginal ribs and lacks a central rib. Along the dorsal margin of the body there is a narrow parasagittal list of subuniform width, extending from the posterior cingular list to the posterior sail; its average width is about half the width of the transverse furrow, and at least in some specimens (Figure 37: 3) it has a fairly great number of cross-ribs.

Megacytic stages have not been recorded.

The dimensions of two specimens were measured.

Dimensions: — Length of body, 68.2–69.7 μ (type, 68.2 μ). Greatest depth of body, 57.0–57.2 μ (type, 57.2 μ).

Variations: — Judging by the two specimens examined, this species is relatively constant.

Comparisons: — *Dinophysis monacantha* is established on outline drawings of two specimens in lateral view, found in the material of the Expedition. The shape of the body in dorsoventral view, the structure of the cingular lists and of the theca are unknown, and the structure of the left sulcal list needs further examination.

The species combines characteristics of *Dinophysis hastata* and *D. uracantha*. In the elongation and relatively large size of the body, and in the posteroventral inclination of the posterior sail, it approaches *D. hastata;* and in the tendency to develop a posterodorsal rather than a posteroventral inclination of the longitudinal axis of the body and in the structure of the posterior sail, it recalls *D. uracantha*. In the position of the posterior sail, it is intermediate between these two species. It differs from both these species in having a parasagittal list along the dorsal margin of the hypotheca.

It resembles *Dinophysis alata* in having a posterior sail and in having a parasagittal list along the dorsal margin of the hypotheca. It is easily distinguished from this species by the more irregular shape of the body, by the subhorizontal position of the cingular lists, by the narrowness of the parasagittal list, and by the

structure of the posterior sail. With regard to the relationships between *D. monacantha*, and *D. urceolus* and *D. trapezium*, see the last two species, the sections on comparisons.

Occurrence: — *Dinophysis monacantha* is recorded at two of the 127 stations. Of these two stations, one (4691) is on the third line of the Expedition and in the Easter Island Eddy; the other (4730), the type locality, is on the fifth line and in the South Equatorial Drift. The depth is 300–0 fathoms, the surface temperature 73°–79°, and the frequency less than 1% (one specimen at each station).

Dinophysis trapezium, sp. nov.

Figure 38: 2, 3

Diagnosis: — Body subtrapeziform in lateral outline, protracted posterodorsally, deepest in or just behind the middle, and 1.23–1.31 times longer than deep; longitudinal axis deflected posterodorsally at about 15°. Cingular lists subhorizontal, subequal, and 1.5–2.5 times wider than transverse furrow. Epitheca visible above anterior cingular list. Left sulcal list: distance between R_1 and R_3 about 0.50 the length of body; R_2 is 0.17–0.21, R_3 is 0.56–0.70 the greatest depth of body; margin forms angle of 35°–55° at R_3; R_3 inclined posteriorly at 15°–25°; reticulated; behind R_3 this list has an acute, wedge-shaped accessory lobe, which has a height 0.28–0.32 the greatest depth of body and an angle at the tip of 30°–40°. With triangular posterior sail somewhat dorsally to midline; length is 0.43–0.50 the greatest depth of body; angle at tip 25°–35°; with marginal ribs; sometimes connected with left sulcal list by very narrow list, sometimes unconnected. Length, 65.2–67.5 μ.

Eastern tropical Pacific.

Description: — This is a medium-sized species, the body of which is subtrapeziform in lateral outline, protracted posterodorsally, and deepest in or just behind the middle. The ratio between the length and the depth of the body is 1.27 (1.23–1.31) : 1. The longitudinal axis is deflected posterodorsally at about 15°.

The epitheca is deep, 0.70–0.72 as deep as hypotheca, flat to slightly convex, highest in the middle or ventrally, and visible above the anterior cingular list. The transverse furrow is flat or gently convex, and about as wide as or somewhat narrower than the greatest height of the epitheca. The posterior cingular list is 0.19–0.22 the length of the body from the apex. The hypotheca is asymmetrical. The dorsal margin (from the girdle to the posterodorsal sail) is almost straight or subuniformly and gently convex. The ventral margin (from the girdle to a point somewhat behind the posterior main rib of the left sulcal list) is gently to

moderately convex. The postmargin is gently to moderately convex, inclined dorsoposteriorly at an angle of 25°–30° to a plane parallel to the girdle, confluent with the ventral margin, and forms with the dorsal margin a distinct but well-rounded corner.

The cingular lists are subhorizontal and subequal, and 1.5–2.5 times wider than the transverse furrow; their structure is unknown. The right sulcal list extends to a point somewhat beyond the fission rib of the left sulcal list; it is either subtriangular, decreasing gradually in width posteriorly, or of subuniform width throughout its anterior half and gently rounded posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is relatively long and strikingly wider posteriorly than anteriorly. The distance between the anterior and posterior main ribs is about 0.50 the length of the body. The anterior main

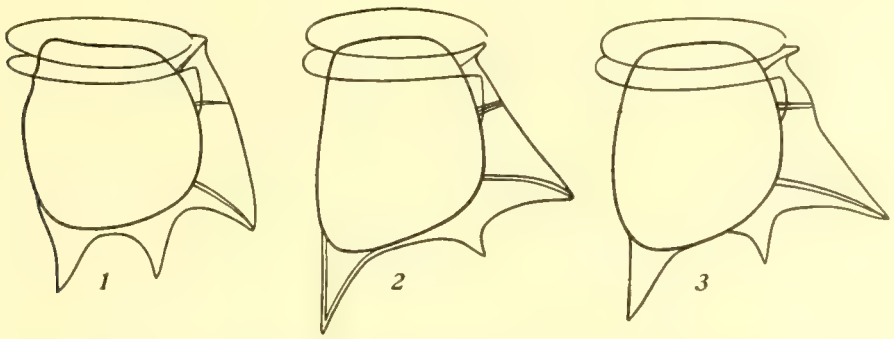

FIGURE 38.— 1, *Dinophysis collaris* Kofoid and Michener, right lateral view. × 430. Station 4711 (300–0 fathoms). 2, 3, *Dinophysis trapezium*, sp. nov., right lateral view. 2, from type specimen. × 430. Station 4709 (300–0 fathoms).

rib is 0.22 (0.20–0.25), the fission rib 0.19 (0.17–0.21), and the posterior main rib 0.63 (0.56–0.70) the greatest depth of the body. Behind the posterior main rib the list decreases suddenly in width. The free margin of this list is almost straight (Figure 38: 2) or slightly irregular (Figure 38: 3) between the anterior and posterior main ribs; at the posterior main rib it forms an angle of 35°–55°; and behind this rib it first is gently concave and then forms an acute, wedge-shaped accessory lobe. This lobe has a height 0.28–0.32 the greatest depth of the body; and the angle at its tip is 30°–40°. The main ribs of this list are of moderate strength and not club-shaped; or the posterior may be slightly club-shaped (Figure 38: 2); the anterior two are straight or almost so, the posterior is slightly to moderately concave posteriorly. The distance between the anterior main rib and the fission rib is 0.30–0.43 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 15°–25°. Besides the main ribs this list has many cross-ribs anastomosing into an irregular reticulum. On the

right valve there is an acute, triangular posterior sail, which is located somewhat dorsally to the midline and has a dorsal inclination of 15°–20° to the midline. When this sail is fully developed, its length is 0.43 0.50 the greatest depth of the body; its margins are almost straight, and the angle at its tip is 25°–35°; it is supported by marginal ribs; sometimes it is connected with the left sulcal list by a very narrow list (Figure 38: 2), and sometimes it is unconnected. As far as we know, there are no parasagittal lists along the dorsal margin of the hypotheca and on the epitheca. The structure of the theca is unknown.

Megacytic specimens have not been recorded.

The dimensions of two specimens were measured.

Dimensions: — Length of body, 65.2–67.5 μ (average, 66.4 μ; type, 67.5 μ). Greatest depth of body, 51.5–52.8 μ (type, 51.5 μ).

Variations: — The two specimens examined are rather similar. They differ mainly in the shape of the hypotheca viewed laterally, in the relative length of the posterior main rib of the left sulcal list, and in regard to the connection between the posterior sail and the left sulcal list.

Comparisons: — *Dinophysis trapezium* is established on two drawings representing the lateral outlines of two specimens from the material of the Expedition. The shape of the body in dorsoventral view, as well as the structure of the cingular lists and of the thecal wall are unknown. The structure of the left sulcal list and of the posterior sail needs to be further examined.

The species is on the border line between the genera Phalacroma and Dinophysis, and its present generic allocation should be regarded as tentative. Its structurally closest-known relative is *Dinophysis collaris* (see this species, the section on comparisons). Next to *D. collaris, D. monacantha* appears to be its nearest relative. It shows a striking resemblance to the last species in the shape of the body in lateral view, in the position of the cingular lists, and in the size, shape, structure, and position of the posterior sail. *D. trapezium* is easily distinguished from *D. monacantha* in having a parasagittal list along the dorsal margin of the hypotheca and in lacking the accessory lobe behind the posterior main rib of the left sulcal list.

Another species which probably is rather closely related to *Dinophysis trapezium* is *D. swezyi.* This relationship is indicated by the similar shape of the body in lateral view (compare Figure 38: 2, 3, and Figure 39: 2, 3) and by the fact that in both these species the left sulcal list has an accessory lobe behind the posterior main rib. *D. swezyi,* which is a typical representative of its genus, is easily recognized by the anterior inclination of its cingular list, by the shape of its

left sulcal list, and by the fact that its posterior sail is supported by a central rib and not by marginal ribs.

Occurrence: — *Dinophysis trapezium* is recorded at only one (4709, the type locality) of the 127 stations, on the fourth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, at a surface temperature of 72°. The frequency is less than 1% (two specimens).

Dinophysis swezyi, sp. nov.

Plate 5, fig. 9. Figure 39

Diagnosis: — Body broadly ovate to rounded subtrapeziform in lateral outline, deepest somewhat behind the middle, 1.12–1.31 times longer than deep; longitudinal axis perpendicular to girdle or deflected posterodorsally at 1°–10°. Cingular lists ribbed, the anterior 2.0–4.0 times wider than transverse furrow. Left sulcal list 0.74–0.83 the length of body; distance between R_1 and R_3 0.55–0.64 the length of body; R_2 is 0.41–0.71, R_3 is 0.73–1.07 the greatest depth of body; margin often strikingly concave just behind R_2 and forms angle of 25°–35° at R_3; R_3 inclined posteriorly at 25°–45° and sometimes club-shaped; behind R_3 this list forms a rounded to subacute accessory lobe, the height of which is 0.25–0.41 the greatest depth of body; between R_2 and R_3 there are a few short basal ribs, and the accessory lobe supported by similar ribs, one of which extends to tip of lobe. With triangular posterior sail, located dorsally to midline, and supported by central rib; its length is 0.69–0.83 the greatest depth of body and 1.9–2.7 its basal width; separated from left sulcal list. Theca reticulate; 11–12 polygons border girdle posteriorly. Length, 47.2–56.4 μ.

Eastern tropical, subtropical, and warm-temperate Pacific.

Description: — This is a medium-sized species, the body of which is broadly ovate to rounded subtrapeziform in lateral outline, and deepest somewhat behind the middle. The ratio between the length and the depth of the body is 1.23 (1.12–1.31): 1. The longitudinal axis is either perpendicular to the girdle or deflected posterodorsally at 8° (1°–10°).

The epitheca is 0.55 (0.50–0.61) as deep as the hypotheca, of moderate to gentle convexity, highest in or somewhat dorsally to the center, and not visible above the anterior cingular list. The transverse furrow is flat or gently convex, and about as wide as or somewhat wider than the greatest height of the epitheca. The posterior cingular list is 0.15 (0.11–0.17) the length of the body from the apex. The hypotheca is very variable in shape. Sometimes (Figure 39: 1) it is symmetrical and broadly ovate; its dorsal and ventral margins are of moderate

and subuniform convexity or either of them is somewhat flattened anteriorly; its postmargin is broadly and subuniformly convex and confluent with the dorsal and ventral margins. In most specimens, however, it is more or less strikingly asymmetrical; its dorsal margin (from the girdle to the posterior sail) is subuniformly and slightly to gently convex, or (Figure 39: 2) it is more or less bulging posteriorly; its ventral margin (from the girdle to the posterior main rib of the left sulcal list) is gently convex; its postmargin is gently to moderately convex, inclined dorsoposteriorly, forming an angle of 25°–35° to a plane parallel to the girdle, confluent with the ventral margin, and forms with the dorsal margin a fairly distinct but well-rounded corner.

The anterior cingular list is 2.8 (2.0–4.0) times wider than the transverse furrow and 0.30–0.33 the greatest depth of the body; it is inclined anteriorly at 20°–30° and has, on each valve, about 13–14 simple, straight, and almost equidistant ribs. The posterior cingular list resembles the anterior but in some specimens it is somewhat narrower or somewhat less inclined anteriorly. The right sulcal list is rather variable; it extends to or somewhat beyond the fission rib of the left sulcal list; sometimes (Figure 39: 3) it is subtriangular, decreasing gradually in width posteriorly; sometimes it is of subuniform width throughout the greater portion of its length and rounded to angular (Plate 5, fig. 9) posteriorly; anteriorly it is about as wide as or somewhat wider than the transverse furrow. The left sulcal list is large. Its length is 0.79 (0.74–0.83) the length of the body, and the distance between the anterior and posterior main ribs is 0.59 (0.55–0.64) the length of the body. The anterior main rib is 0.25 (0.21–0.29), the fission rib 0.59 (0.41–0.71), and the posterior main rib 0.89 (0.73–1.07) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior main rib and the fission rib the free margin of this list is almost straight or slightly concave, convex, or sigmoid; between the fission rib and the posterior main rib it is concave, and the concavity usually is very striking just behind the fission rib. At the posterior main rib this margin forms an angle of 28° (25°–35°), and behind this rib it first is gently concave and then forms a more or less narrowly rounded to subacute accessory lobe, the height of which is 0.32 (0.25–0.41) the greatest depth of the body. The main ribs are of moderate strength, and the fission rib and the posterior main rib sometimes are club-shaped. The anterior main rib is straight or nearly so; the fission rib and the posterior main rib usually are gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.48 (0.45–0.50) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 36°

(25°–45°). Between the fission rib and the posterior main rib there are a few (about three) short ribs, and the posterior accessory lobe is supported by similar ribs, one of which extends to the tip of the lobe (Plate 5, fig. 9). On the right valve there is an acute posterior sail, situated somewhat dorsally to the midline, and supported by a central rib, which is gently concave ventrally and which may be club-shaped (Figure 39: 2) or split lengthwise (Plate 5, fig. 9). When this sail is fully developed, its length is 0.75 (0.69–0.83) the greatest depth of the body and 2.3 (1.9–2.7) its basal width; except for the central rib it lacks structural differentiation, and it is separated from the left sulcal list by a distance equaling 0.34 (0.27–0.42) the greatest depth of the body. There are no parasagittal lists along the dorsal margin of the hypotheca and on the epitheca. The thecal wall is reticulate and porulate. About 11–12 polygons border the girdle posteriorly. In the girdle there are two rows of meshes.

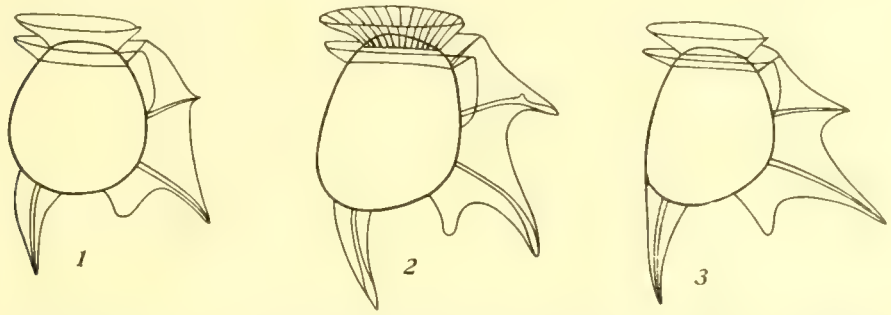

FIGURE 39.— *Dinophysis swezyi*, sp. nov., right lateral view. × 430. 1, from Station 4679 (300–0 fathoms); 2, from Station 4638 (300–0 fathoms); 3, from Station 4732 (300–0 fathoms).

Megacytic stages have not been reported.

The dimensions of three specimens from the material of the Expedition and of the type specimen were measured.

This species is named for Dr. Olive Swezy, the collaborator with the senior author in the preparation of "The Free-living Unarmored Dinoflagellata," who during her investigations on the dinoflagellates of the San Diego region made our drawing of the type specimen (Plate 5, fig. 9) as well as sketches of several other specimens of this species.

Dimensions: — Length of body, 47.2–56.4 μ (average, 52.1 μ; type, 55.0 μ). Greatest depth of body, 39.2–44.8 μ (average, 42.3 μ; type, 44.8 μ).

Variations: — This species is rather constant except in the shape of the body in lateral view and in the shape of the free margin of the left sulcal list between the fission rib and the posterior main rib, in which respects it is strikingly variable. The body usually is more or less asymmetrical, rounded subtrapeziform, and pro-

tracted posterodorsally, but sometimes (Figure 39: 1) it is symmetrical and broadly ovate. The margin of the left sulcal list between the fission rib and the posterior main rib usually is deeply concave just behind the fission rib, but sometimes (Figure 39: 1) it is gently and subuniformly concave. Other characters exhibiting variations are: the shape and size of the right sulcal list, the shape and relative length of the fission rib and of the posterior main rib of the left sulcal list and of the central rib of the posterior sail; and the shape of the accessory lobe of the left sulcal list. The specimen represented by Figure 39: 1, may be specifically different from the other specimens assigned to this species.

Comparisons: — This species is rather closely related to *Dinophysis trapezium* and *D. schütti.* Its relationship to *D. trapezium* is indicated by the shape of the body in lateral view (compare Figure 39: 2, 3, and Figure 38 : 2, 3) and by the fact that in both these species the left sulcal list has an accessory lobe behind the posterior main rib. Its relationship to *D. schütti* is suggested by the shape of the body in lateral view (compare Figure 39: 2, 3, and Figure 40: 3, 5), by the shape of the ventral margin of the left sulcal list, and by the shape, structure, and relative size of the posterior sail. *D. swezyi* is easily distinguished from *D. trapezium* by the shape of the ventral margin of its left sulcal list, by the anterior inclination of its cingular lists, and by its posterior sail being supported by a central rib and not by marginal ribs. It differs from *D. schütti* especially in having the left sulcal list with an accessory lobe behind the posterior main rib.

Occurrence:—*Dinophysis swezyi* is recorded at four of the 127 stations. There are 0, 1, 1, 0, 2, and 0 stations on the six lines of the Expedition. Of these four stations, one (4638) is in the Panamic Area; and three (4679, 4732, 4737) are in the South Equatorial Drift. At one of these stations (4737) the species was taken in a haul from 100–0 fathoms. All the other records refer to hauls from 300–0 fathoms.

The temperature range of these four stations at the surface was 69.0°–81.5°; the average was 76.1°.

The frequency is in every case less than 1%.

The type specimen (Plate 5, fig. 9) was taken at San Diego, California, where this species has been found on several occasions.

Dinophysis collaris Kofoid and Michener

Plate 5, fig. 2, 8. Figure 38: 1

Dinophysis collaris Kofoid & Michener, 1911, p. 292.

Diagnosis: — Body rounded trapeziform in lateral outline, deepest in the middle, 1.05–1.07 times longer than deep; longitudinal axis deflected postero-

dorsally at 10°–15°. In dorsal view about three times longer than wide, widest at girdle, with almost straight side contours and rounded apices. Cingular lists subhorizontal, subequal, 1.5–2.5 times wider than transverse furrow, and ribbed. Epitheca visible above anterior cingular list. Left sulcal list: distance between R_1 and R_3, 0.55–0.59 the length of body; R_2 is 0.21–0.22, R_3 is 0.39–0.43 the greatest depth of body; margin forms angle of 35°–65° at R_3; R_3 inclined posteriorly at 30°–40°; reticulated. Two parasagittal lists encircle hypotheca. The left is of subuniform width throughout, 0.5 as wide as transverse furrow. The right continues left sulcal list and forms two subequal, acute, wedge-shaped posterior sails, one on each side of midline, both with irregularly anastomosing ribs; length of sails somewhat less than R_3; angles at their tips 30°–50°; width of list between sails and between ventral sail and R_3 subequal to width of transverse furrow or less. Theca reticulate; 25–30 polygons border girdle posteriorly. Length, 58.0–67.0 μ.

Eastern tropical and subtropical Pacific.

Description: — This is a medium-sized species, the body of which is rounded trapeziform in lateral outline, and deepest near the middle. The ratio between the length and the depth of the body is 1.05–1.07: 1. The longitudinal axis is deflected posterodorsally at 10°–15°.

The epitheca is very deep, 0.73–0.74 as deep as the hypotheca, flat or even gently concave, highest dorsally, and visible above the anterior cingular list. The transverse furrow is flat or gently concave, and about as wide as or slightly wider than the greatest height of the epitheca. The posterior cingular list is 0.17–0.21 the length of the body from the apex. The hypotheca is asymmetrical. The dorsal margin is sigmoid, being slightly to moderately concave anteriorly, gently to moderately convex in the middle, and more or less flattened posteriorly. The ventral margin (from the girdle to the posterior end of the left sulcal list) is subuniformly, and gently to moderately convex. The postmargin is gently to moderately convex and is inclined dorsoposteriorly, forming an angle of about 10°–25° to a plane parallel to the girdle. In dorsoventral view the body is bilaterally compressed, widest at the girdle, about three times longer than wide, with almost straight side contours, and with rounded apices.

The anterior cingular list is 1.5–2.5 times wider than the transverse furrow and 0.17–0.22 the greatest depth of the body; usually it is subhorizontal, but sometimes it has an anterior inclination of about 10°–20°; on each valve it has 15–20 simple, straight, and almost equidistant ribs. The posterior cingular list may be somewhat narrower than but usually it is about as wide as the anterior; it is subhorizontal and has about the same ribbing as the anterior. The sulcus is

about 0.40–0.45 as long as the hypotheca. The flagellar pore is located at a distance from the girdle subequal to the width of the transverse furrow. The right sulcal list extends to a point somewhat beyond the fission rib of the left sulcal list, and is subtriangular, decreasing gradually in width posteriorly; anteriorly it is about as wide as the transverse furrow. The left sulcal list is of moderate width and rather long. The distance between the anterior and posterior main ribs is 0.55–0.59 the length of the body. The anterior main rib is 0.19–0.24, the fission rib 0.21–0.22, and the posterior main rib 0.39–0.43 the greatest depth of the body. Behind the posterior main rib the list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is almost straight, or gently to moderately convex; the convexity is either subuniform or somewhat irregular (Plate 5, fig. 2). At the posterior main rib this margin forms an angle of 35°–65°; behind this rib it is gently concave. The main ribs of this list are of moderate strength and not club-shaped; the anterior two are straight or almost so, the posterior, which sometimes is branched (Plate 5, fig. 2), is slightly to moderately concave posteriorly. The distance between the anterior main rib and the fission rib is 0.30–0.33 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 30°–40°. Besides the main ribs this list has many cross-ribs anastomosing into a very irregular reticulum. The epitheca has no accessory lists. The hypotheca, on the other hand, has two parasagittal lists, which sometimes are limited to the postmargin (Figure 38: 1), but usually continue to the posterior cingular list. The left one of these lists is of subuniform width throughout, and its average width is about half the width of the transverse furrow; sometimes it has no distinct structural differentiation, sometimes it has a few cross-ribs. The right, which forms a direct continuation of the left sulcal list, resembles the left but is characterized by two subequal, acute, wedge-shaped posterior sails, one on either side of the midline, and both furnished with irregularly anastomosing ribs. The length of the dorsal sail is 0.31 (0.25–0.37), that of the ventral sail 0.31 (0.27–0.35) the greatest depth of the body; in other words, these sails are somewhat shorter than the posterior main rib of the left sulcal list. The angles at their tips are about 30°–50°. The width of the right parasagittal list, between the left sulcal list and the ventral sail and between the two sails, is subequal to the width of the transverse furrow or less.

The surface of the theca is uniformly covered with small, irregular polygons of heavy mesh. On each valve about 25–30 polygons border the girdle posteriorly. In the transverse furrow there are two rows of polygons, each row with 15–25 polygons on each valve.

Megacytic specimens have not been recorded.

The dimensions of two of our specimens were measured.

Dimensions: — Length of body, 58.0–67.0 μ (average, 62.5 μ; type, 67.0 μ, not 58 μ, as stated in the original description). Greatest depth of body, 55.4–62.5 μ (average, 58.9 μ; type, 62.5 μ, not 55 μ, as stated in the original description).

Variations: — Judging by the few specimens examined, this species appears to be rather constant. The most variable character is the extension of the parasagittal lists. Sometimes these lists are limited to the postmargin of the body, sometimes they continue along the whole dorsal margin of the hypotheca to the posterior cingular list. These variations presumably are related to skeletal reorganization consequent upon binary fission.

Comparisons: — Our description and figures of *Dinophysis collaris* are based on the type material.

The generic assignment of this species is uncertain, and its present allocation should be regarded as tentative. The great relative depth of the epitheca, the subhorizontal position of the cingular lists, the ribbing of the posterior cingular list, the presence of parasagittal lists on the dorsal side of the hypotheca, and the reticulation of the thecal wall affiliate it with Phalacroma. On the other hand, the posterodorsal inclination of the longitudinal axis of the body, the shortness of the epitheca, the shape of the hypotheca in lateral view, and the great width of the cingular lists suggest relationship to Dinophysis. Two posterior sails are to be found in Dinophysis as well as in Phalacroma. The species shows that the separation of these two genera is almost arbitrary.

The structurally closest-known relative of *Dinophysis collaris* is *D. trapezium*. The former species differs from the latter mainly in the less-pronounced trapeziform shape of its body, in having its body less protracted posterodorsally, in the shorter posterior main rib of its left sulcal list, in the subequal size of its two posterior sails, and in having these sails supported by irregularly anastomosing ribs (see also *D. trapezium*, the section on comparisons).

Another close relative of *Dinophysis collaris* is *D. urceolus*. This relationship is indicated by the almost complete agreement in the lateral shape of body in these two species. The latter species, which is a rather typical representative of Dinophysis, is easily distinguished from the former by having only one posterior sail, viz., the one situated dorsally to the midline of the body.

Among the species of Phalacroma, *P. bipartitum* resembles *Dinophysis collaris* in the structural differentiation of the parasagittal list of the right valve. *Dinophysis collaris* is easily distinguished from *Phalacroma bipartitum* by the

rather irregular shape of its body, by its much lower epitheca, and by its larger and more differentiated cingular and sulcal lists.

Occurrence: — This species is recorded at six of the 127 stations. There are 0, 1, 2, 2, 1, and 0 stations on the six lines of the Expedition. Of these six stations one (4671) is in the Peruvian Current; one (4713) is in the Galapagos Eddy; and four (4679, 4681, 4711, 4730) are in the South Equatorial Drift. All the records refer to catches from 300–0 fathoms.

The temperature range of these six stations at the surface was 66°–79°; the average was 71.7°.

The frequency in every case is less than 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) at Station 4671 of the Expedition, which thus is the type locality.

The prevalence of this species in the Peruvian Current and in the regions directly influenced by this current, as well as its absence from the California Current, the Mexican Current, and the Panamic Area may be noteworthy.

Dinophysis schütti Murray and Whitting

Figure 40, 41

Dinophysis schuettii Murray & Whitting, 1899, p. 331, tab. 8, pl. 31, fig. 10. Lemmermann, 1899a, p. 373; 1901a, p. 375. Ostenfeld, 1900, p. 56, tab. 2. Cleve, 1901a, p. 15. Kofoid, 1907a, p. 196. Karsten, 1907, p. 421, 473. Paulsen, 1908, p. 12, 18, fig. 19. Nathansohn, 1908, p. 604; 1909, p. 46. Meunier, 1910, p. 58. Pavillard, 1916, p. 60. Jörgensen, 1923, p. 34, 44, fig. 46.
Dinophysis uracantha Schütt (*non* Stein), 1895, p. 16, 17, pl. 2, fig. 9.
Dinophysis schuettii var. *uracanthoides* Forti & Issel, 1924, p. 6, fig. 2.

Diagnosis: — Body subovate to subellipsoidal in lateral outline, deepest near the middle; length: depth, 1.09–1.23: 1; longitudinal axis deflected posterodorsally at 0°–6°. In dorsal view rather narrowly ellipsoidal, 1.45 times longer than wide. Anterior cingular list 2.0–3.0 times wider than transverse furrow. Left sulcal list 0.68–0.84 the length of the body; distance between R_1 and R_3 0.58–0.68 the length of body; R_2 is 0.85–1.25, R_3 is 0.89–1.33 the greatest depth of body; margin strongly concave between R_2 and R_3 and forms angle of 5°–15° at R_3; R_3 inclined posteriorly at angle of 30°–55°; R_2 and R_3 often club-shaped; sometimes slightly reticulated. With triangular posterior sail located somewhat dorsally to midline; its length is 0.81–1.35 the greatest depth of body and 1.7–4.0 its basal width; supported by central rib, which often is club-shaped distally and sometimes bifurcate or trifurcate proximally; separated from left sulcal list. Theca finely and closely areolate. Length, 29.6–62.0 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas, seldom in colder waters.

Description: — This is a small to medium-sized species, the body of which is subovate to subellipsoidal in lateral outline and deepest near the middle. The ratio between the length and the depth of the body is 1.09–1.23: 1; in our specimens this ratio is 1.21 (1.19–1.23): 1; in the specimens figured by Schütt (1895), Murray and Whitting (1899), and Jörgensen (1923) it varies between 1.09: 1 and 1.11: 1. The longitudinal axis either is perpendicular to the transverse furrow, as in our Figure 40: 1, 6, or it is deflected posterodorsally at an angle of 2° (1°–6°).

The epitheca is 0.30–0.50 as deep as the hypotheca, moderately to rather strongly convex, highest in or just dorsally to the center, and not visible above the anterior cingular list. The transverse furrow is flat or gently convex, and in most specimens about 2.0–3.0 times wider than the greatest height of the epitheca. The posterior cingular list is 0.15 (0.13–0.17) the length of the body from the apex. The hypotheca sometimes is symmetrical, as in Figure 40: 1, 6, but usually it has a slight posterodorsal inclination (see above). The dorsal margin (from the girdle to the antapex) sometimes is subuniformly and moderately to gently convex, and sometimes (Figure 40: 5) it is flattened anteriorly and boldly convex posteriorly. The ventral margin (from the girdle to the antapex) is subuniformly and moderately to rather strongly convex, or it is somewhat flattened posteriorly (Figure 40: 5); its curvature either is about the same as that of the dorsal margin, or it is more pronounced, in which case the body appears to be flattened dorsally (Figure 40: 3). The apices sometimes are of about the same depth, but usually the body is distinctly deeper posteriorly than anteriorly. In dorsoventral view the body is rather narrowly ellipsoidal, widest in the middle, about 1.45 times longer than wide, and with the apices well rounded and of about the same width.

The anterior cingular list is 2.0–3.0 times wider than the transverse furrow and 0.30–0.50 the greatest depth of the body; it has a well-developed funnel-shape, being inclined anteriorly at 20°–40°, and, on each valve, is furnished with about ten to twenty simple, straight, and almost equidistant ribs, some of which may be incomplete. The posterior cingular list may be about as wide as the anterior, but usually it is somewhat narrower; its inclination usually is about the same as that of the anterior, and it appears always to lack structural differentiation. The right sulcal list extends to or slightly beyond the fission rib of the left sulcal list, and is subtriangular, decreasing gradually in width posteriorly, or of subuniform width throughout the greater part of its length and rounded posteriorly; anteriorly it is about as wide as or somewhat wider than the transverse

furrow. The left sulcal list is unusually large, with very long fission rib and posterior main rib. Its length is 0.74 (0.68–0.84) the length of the body, and the distance between the anterior and posterior main ribs is 0.63 (0.58–0.68) the length of the body. The anterior main rib is 0.34 (0.27–0.42), the fission rib 1.04 (0.85–1.25), and the posterior main rib 1.07 (0.89–1.33) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. The ventral margin of this list sometimes (Figure 40: 2, 4) extends to the tips of the fission rib and the posterior main rib, but usually it terminates at some distance from the tips, and the distal portions of these two ribs are free; the length of the free portions may even slightly exceed half the length of these ribs. Between the anterior main rib and the fission rib the margin is almost straight or gently concave; between the fission rib and the posterior main rib it is strongly concave; at the posterior main rib it forms an angle of 9° (5°–15°), and behind this rib it is gently to moderately concave or almost straight. The main ribs of this list sometimes are straight, sometimes the fission rib and the posterior main rib are concave posteriorly; the two last ribs frequently are club-shaped distally. The distance between the anterior main rib and the fission rib is 0.43 (0.33–0.50) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 47° (30°–55°). Besides the three main ribs this list sometimes has a slight indication of reticulation (Schütt, 1895, pl. 2, fig. 9: 3). On the right valve there is an acute, triangular posterior sail, which is situated somewhat dorsally to the midline and usually directed posterodorsally at an angle of about 10°. The left sulcal list ends at a distance from the posterior sail equaling 0.51 (0.42–0.61) the greatest depth of the body. When the posterior sail is fully developed, its length is 1.00 (0.81–1.35) the greatest depth of the body; *i.e.*, its average length is subequal to that of the posterior main rib of the left sulcal list; and it is 2.9 (1.7–4.0) times longer than it is wide at the base. Sometimes both its margins are almost straight or slightly concave, but usually its dorsal margin is gently convex and its ventral margin gently concave; the angle at its tip is about the same as that at the tip of the posterior main rib of the left sulcal list. The posterior sail is supported by a central rib. This rib, which frequently is club-shaped distally, sometimes is straight and sometimes gently concave ventrally; in some specimens its base is bifurcate or trifurcate; sometimes the sail extends to the tip of this rib, sometimes it terminates at some distance from the tip, and the distal portion of the rib is free; the length of the free portion, which is variable, may exceed half the length of the rib. No parasagittal lists are developed. The thecal wall is finely and closely areolate and has scattered pores

(Schütt, 1895, pl. 2, fig. 9: 3). According to Schütt (1895, p. 64), this species lacks chromatophores.

Megacytic stages have not been recorded.

The dimensions of eight of our specimens and of the specimens figured by Schütt (1895), Murray and Whitting (1899), and Jörgensen (1923) were measured.

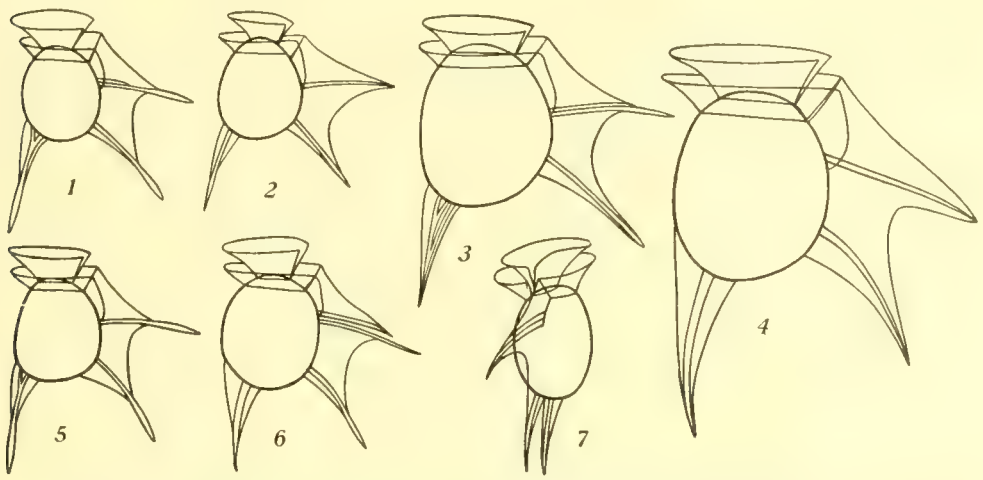

FIGURE 40.— *Dinophysis schütti* Murray and Whitting, all, except 7, in right-lateral view; 7, in ventral view; 6 and 7, from the same specimen. × 430. 1, from Station 4730 (300–0 fathoms); 2, from Station 4732 (300–0 fathoms); 3, from Station 4697 (300–0 fathoms); 4, 6, 7, from Station 4679 (300–0 fathoms); 5, from Station 4701 (300–0 fathoms).

Dimensions: — Four of our large specimens: Length of body, 49.8–57.7 μ (average, 52.6 μ). Greatest depth of body, 40.5–47.8 μ (average, 43.2 μ). Four of our small specimens: Length of body, 29.6–35.5 μ (average, 32.2 μ). Greatest depth of body, 24.7–29.1 μ (average, 27.7 μ). The specimen represented by Schütt's (1895) Plate 2, figure 9: 1, was 45.3 μ long and 41.4 μ deep. The type specimen, as figured by Murray and Whitting (1899, pl. 31, fig. 10), was 37.5 μ long and 34.1 μ deep. The specimens measured by Jörgensen (1923) formed two size classes, the larger specimens being 54–62 μ long and 45–47 μ deep, the smaller 40–43 μ long and 32–36 μ deep.

Variations: — *Dinophysis schütti,* as conceived in this paper, is rather strikingly variable, and a future subdivision of this species is not excluded. The following characters are the most variable: — the size of the body, the shape of the hypotheca, the width of the cingular lists, the shape of the left sulcal list and the shape and relative lengths of its ribs, and the structure of the midrib of the posterior sail.

Comparisons: — Jörgensen (1923, p. 34) writes about this species as follows: "It occurs in two forms, a larger, 54–62 μ long by 45–47 μ broad, often with

downward curving ventral spines, and a smaller, 40–43 μ by 32–36 μ, generally with straight ventral spines." Our specimens of this species also form two distinct size classes: the specimens of the larger class are 52.6 (49.8–57.7) μ long and 43.2 (40.5–47.8) μ deep; the smaller class comprises specimens 32.2 (29.6–35.5) μ long and 27.7 (24.7–29.1) μ deep. The type specimen, figured by Murray and Whitting (1899, pl. 31, fig. 10), is 37.5 μ long and 34.1 μ deep and thus belongs to the small size class. The specimen figured by Schütt (1895, pl. 2, fig. 9: 1) is 45.3 μ long and 41.4 μ deep and should be referred to the larger size class.

Do these size classes represent two different systematic units, or only developmental or cyclic stages of one and the same species? The very marked discontinuity in the size-frequency distribution of Jörgensen's (1923) specimens as well as of those examined by us undoubtedly seems to indicate that these classes are systematically distinct. On the other hand, no correlation has been found between any morphological character and the size of the body. In the following the main results of an attempt to establish a correlation of this kind will be given.

In our large specimens the ratio between the length and the greatest depth of the body is 1.22 (1.21–1.23): 1; in our small specimens, 1.20 (1.19–1.22): 1. In the specimens figured by Schütt (1895), Murray and Whitting (1899), and Jörgensen (1923) this ratio varies between 1.09: 1 and 1.11: 1. In other words, in our large specimens this ratio is about the same as in our small specimens, and the difference established has no systematic importance as is shown by a comparison with the corresponding ratio in the specimens figured by Schütt (1895), Murray and Whitting (1899), and Jörgensen (1923).

The ratios between the lengths of the three main ribs of the left sulcal list and the greatest depth of the body are to be found in the following table.

	R_1	R_2	R_3
Our large specimens:	0.33 (0.27–0.40)	0.96 (0.85–1.07)	1.06 (1.00–1.10)
Our small specimens:	0.35 (0.31–0.42)	1.17 (1.07–1.25)	1.15 (1.00–1.33)
Schütt (1895, fig. 9: 1):	0.33	0.89	0.89
Murray and Whitting (1899, pl. 31, fig. 10):	0.29	0.87	0.98
Jörgensen (1923, fig. 46):	0.31	0.93	1.08

Our large specimens thus have, on the average, relatively shorter ribs in the left sulcal list than have our small specimens. However, that the difference established has no systematic value is again indicated by a comparison with the corresponding ratios in the specimens figured by Schütt (1895), Murray and Whitting (1899), and Jörgensen (1923). For instance, in spite of its small size,

the specimen figured by Murray and Whitting (1899) has these ribs comparatively shorter than in our large specimens.

The ratio between the width of the anterior cingular list and the greatest depth of the body, the curvature of the ribs of the left sulcal list (mentioned by Jörgensen, 1923), the shape of the left sulcal list, and other characters exhibiting variations in this species have also been tested in order to establish a morphological difference between the two size classes. In these cases, too, the results were negative. Under these circumstances we have judged it most advisable to accept Jörgensen's (1923) decision; and so we have treated these two size classes as systematically identical.

Dinophysis schütti is structurally closely related to *D. swezyi*, from which it is distinguished mainly by the fact that its left sulcal list lacks an accessory lobe just behind the posterior main rib. Other close relatives of *D. schütti* probably are *D. hastata*, *D. uracantha*, *D. triacantha*, *D. jörgenseni*, and *D. nias*. *D. schütti* is easily distinguished from *D. hastata* and *D. uracantha* by the great length of the fission rib of its left sulcal list and the shape of the ventral margin of this list. From *D. triacantha*, *D. jörgenseni*, and *D. nias*, it is easily distinguished by having only one posterior sail.

Synonymy: — This species was established by Murray and Whitting (1899), who described and figured it under the name of *Dinophysis schüttii*. However, it had been figured previously by Schütt (1895) under the name of *D. uracantha* Stein. Jörgensen (1923) described and figured this species, Paulsen (1908) described it; both used the name *D. schütti*. Paulsen (1908) gave a reproduction of Murray and Whitting's (1899) figure of the type specimen. Murray and Whitting (1899), Paulsen (1908), and Jörgensen (1923) wrote *D. uracantha* Schütt (1895) as a synonym of *D. schütti*. The form described and figured by Forti and Issel (1924) under the name of *D. schuettii* var. *uracanthoides*, is, according to our opinion, not systematically different from the main species but should be regarded as one of the several modifications occurring in this.

According to Jörgensen (1923, p. 34), Ostenfeld's (1900) record of *Dinophysis schütti* from the northern Atlantic "is perhaps due to confusion with some other form (*Dinophysis uracantha*?)." There are no facts available supporting this assumption. Ostenfeld (1900) does not give any figure, but he refers his readers to Murray and Whitting's (1899) Plate 31, figure 10, of *D. schütti*. Under these circumstances we accept Ostenfeld's (1900) assignment and consider the specimen recorded by him as a straggler of southern origin carried to the north by the Gulf Stream.

Occurrence: — *Dinophysis schütti* is recorded at twenty-two of the 127 stations. There are 1, 1, 7, 8, 4, and 1 stations on the six lines of the Expedition. Of these twenty-two stations, one (4587) is in the Mexican Current; two (4652, 4676) are in the Peruvian Current; five (4689, 4691, 4695, 4697, 4699) are in the Easter Island Eddy; two (4713, 4715) are in the Galapagos Eddy; and twelve (4679, 4681, 4683, 4687, 4701, 4705, 4711, 4722, 4730, 4732, 4736, 4740) are in the South Equatorial Drift. At one of these stations (4676) the species was taken in a surface haul as well as in a haul from 300–0 fathoms; at one station (4652) in a haul from 100–0 fathoms; at one station (4689) in a haul from 800–0 fathoms; at one

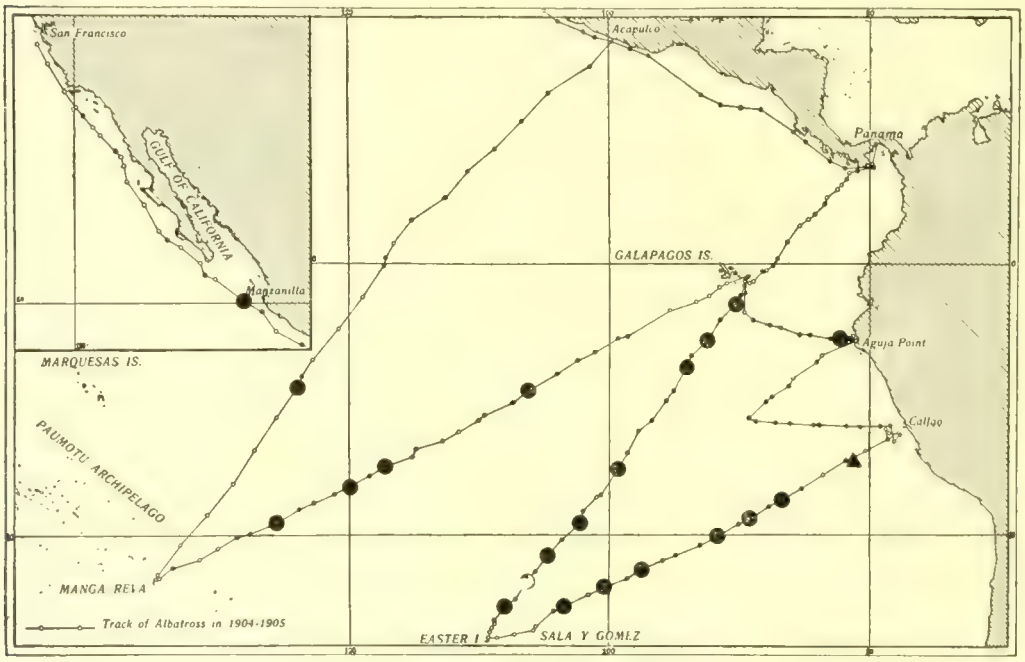

FIGURE 41.— Occurrence of *Dinophysis schütti* Murray and Whitting. Large, solid circles indicate records from vertical hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

station (4681) in hauls from 800–0 fathoms and 300–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these twenty-two stations at the surface was 66°–82°; the average was 74.0°. At Station 4676, where the species was taken in a surface haul, the surface temperature was 69°.

The frequency is 2% at one station (4695), 1% at four stations (4681, 4689, 4699, 4701), and less than 1% at the remaining stations.

Schütt (1895), who was the first to treat this species, did not give any information as to the localities of his specimens; however, his material probably

was taken either in the tropical or subtropical Atlantic or at Naples. Murray and Whitting (1899) recorded the species from the Sargasso Sea, lat. 29° 20′ N.–31° 20′ N., long. 44° 50′ W.–42° 30′ W. Ostenfeld (1900) found it at lat. 59° 47′ N., long. 25° 53′ W., *i.e.*, about midway between the northern point of Scotland and the southern point of Greenland; Jörgensen (1923), in the Bay of Cadiz. According to Jörgensen (1923, p. 34), the species "occurs in the tropical and subtropical Atlantic, especially south of the equator"; however, there is no information as to what material this statement is founded upon. In the Mediterranean it has been found by the following authors: — in the Gulf of Lyons, by Pavillard (1916); off Monaco, by Nathansohn (1908, 1909); in the Adriatic Sea, by Forti and Issel (1924); and at several stations in different regions of this sea, by Jörgensen (1923). From the Marmora Sea it is reported by Jörgensen (1923), and from the Indian Ocean, at lat. 7°–3° N., long. 73°–86° E., by Cleve (1901a).

Murray and Whitting (1899) recorded a temperature of 67° for this species; Ostenfeld (1900), a temperature of 45.3° and a salinity of 35.21.

Of the authors mentioned in connection with the distribution of this species, only Schütt (1895), Murray and Whitting (1899), Jörgensen (1923), and Forti and Issel (1924) give descriptions or figures by means of which their determinations of this form may be checked.

This is a eupelagic species, widely distributed in tropical, subtropical, and warm-temperate seas. On one occasion it was recorded as far to the north as in the Irminger Sea, but the specimen found in this relatively cold region was presumably a straggler of southern origin, carried to the north by the Gulf Stream. Its distribution in the Eastern Pacific, according to our data, is peculiar in so far as it has never been found in the California Current and in the Panamic Area and only once in the Mexican Current; its relatively frequent occurrence in the Easter Island Eddy is also noteworthy. Its optimum habitat presumably is in deeper waters, within the levels of photosynthesis.

Dinophysis nias Karsten

Figure 42: 1

Dinophysis nias Karsten, 1907, p. 262, 421, 473, 540, pl. 47, fig. 7.
Dinophysis triacantha Karsten, 1907, p. 421, 540, pl. 47, fig. 7.

Diagnosis: — Body subovate in lateral outline, deepest somewhat behind the middle; length: depth, 1.18–1.23: 1; longitudinal axis deflected posteroventrally at 10°–15°. Both cingular lists ribbed; the anterior 3.0 times wider than transverse furrow. Left sulcal list 0.62–0.67 the length of body; distance between R_1 and R_3

0.50–0.53 the length of body; R_2 is 0.25–0.31, R_3 is 0.84–0.92 the greatest depth of body; margin forms angle of 10°–15° at R_3; R_3 inclined posteriorly at 30°. With two acute posterior sails, one on each side of midline, each supported by central rib which may be bifurcate basally. Ventroposterior sail 0.82–0.83 the greatest depth of body in length, 3.0 3.3 times longer than its basal width, and separated from left sulcal list and dorsal posterior sail by distance equaling or somewhat exceeding its basal width. Dorsoposterior sail 0.63–0.78 the greatest depth of body in length and 2.2–3.0 times longer than its basal width. Except for central ribs posterior sails appear to lack structure. Theca finely and closely areolate. Length, 52.2–56.0 μ.

Probably widely distributed in tropical seas.

Description: — This is a medium-sized species, subovate in lateral outline, subtruncate anteriorly, and deepest somewhat behind the middle. The ratio between the length and the depth of the body is 1.18–1.23: 1. The longitudinal axis is deflected posteroventrally at about 10°–15°.

The epitheca is about 0.54 as deep as the hypotheca, gently convex, highest in the center, and not visible above the anterior cingular list. The transverse furrow is flat or gently convex and about twice as wide as the greatest height of the epitheca. The posterior cingular list is about 0.13 the length of the body from the apex. The hypotheca has a rather pronounced posteroventral inclination (see above). The dorsal margin (from the girdle to the antapex) has a subuniform and moderate convexity. The ventral margin (from the girdle to the antapex) is rather strongly convex posteriorly and more or less flattened anteriorly. The posterior end of the body is distinctly deeper than the anterior.

The anterior cingular list is about 3.0 times wider than the transverse furrow and 0.33–0.40 the greatest depth of the body; it is inclined anteriorly at about 40°–50° and has, on each valve, about 11–12 simple, straight, and almost equidistant ribs (Karsten, 1907, pl. 47, fig. 7). The posterior cingular list is about as wide as or somewhat narrower than the anterior, inclined anteriorly at about 40°, and has, on each valve, about 13–14 simple, straight, and nearly equidistant ribs (Karsten, 1907, pl. 47, fig. 7). Judging by Karsten's (1907) figure, the right sulcal list extends to the fission rib of the left sulcal list and is subtriangular, decreasing in width posteriorly. The left sulcal list is strikingly wider posteriorly than anteriorly. Its length is 0.62–0.67 the length of the body, and the distance between the anterior and posterior main ribs is 0.50–0.53 the length of the body. The anterior main rib is 0.22–0.28, the fission rib 0.25–0.31, and the posterior main rib 0.84–0.92 the greatest depth of the body. Behind the posterior main rib this list

decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is almost straight or slightly undulating (Karsten, 1907, pl. 47, fig. 7). At the posterior main rib the list is acuminate, and the margin forms an angle of 10°–15°. Behind this rib the margin is moderately convex or sigmoid. The main ribs are of moderate strength and not club-shaped or otherwise modified; the two anterior are straight or almost so, the posterior is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.45–0.50 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of about 30°. Except for the main ribs, this list appears to lack ribs. On the right valve there are two acute posterior sails, one on each side of the midline, each supported by a central rib which is gently concave ventrally and which may be bifurcate basally. The ventroposterior sail is 0.82–0.83 the greatest depth of the body in length, 3.0–3.3 times longer than its basal width, and directed posteroventrally; its ventral margin is gently concave, its dorsal margin gently convex, and the angle at its tip about 10°–15°; it is separated from the left sulcal list and from the dorsal posterior sail by distances equaling or somewhat exceeding its basal width. The dorsoposterior sail is 0.63–0.78 the greatest depth of the body in length, 2.2–3.0 times longer than its basal width, and directed posterodorsally; its ventral margin is gently concave, its dorsal margin gently convex, and the angle at its tip about 15°. With the exception of the central ribs, the posterior sails appear to lack structural differentiation. There are no parasagittal lists along the dorsal margin of the hypotheca and on the epitheca. The thecal wall is finely and closely areolate and has scattered pores. The areoles are of about the same size as the pores.

Megacytic stages have not been recorded.

The dimensions of one specimen from the material of the Expedition and of the type specimen, as figured by Karsten (1907, pl. 47, fig. 7), were measured.

Dimensions: — Our specimen: Length of body, 56.0 μ. Greatest depth of body, 47.2 μ. The type specimen, as figured by Karsten (1907, pl. 47, fig. 7), was about 52.2 μ long and 42.6 μ deep.

Variations: — Judging by the two specimens hitherto figured, one of which was taken off the coast of Sumatra, the other in the eastern tropical Pacific, this species appears to be rather constant.

Comparisons: — The specimen found in the material of the Expedition resembles closely the type specimen, as figured by Karsten (1907). It differs mainly in having the two posterior sails subequal and (possibly) in its somewhat narrower anterior cingular list.

The structurally closest-known relatives of *Dinophysis nias* are *D. triacantha* and *D. jörgenseni* (see the last two species, the sections on comparisons). *D. nias* is easily recognizable by the straight or nearly straight ventral margin of its left sulcal list, and by having its two posterior sails free, *i.e.*, connected neither with each other nor with the left sulcal list.

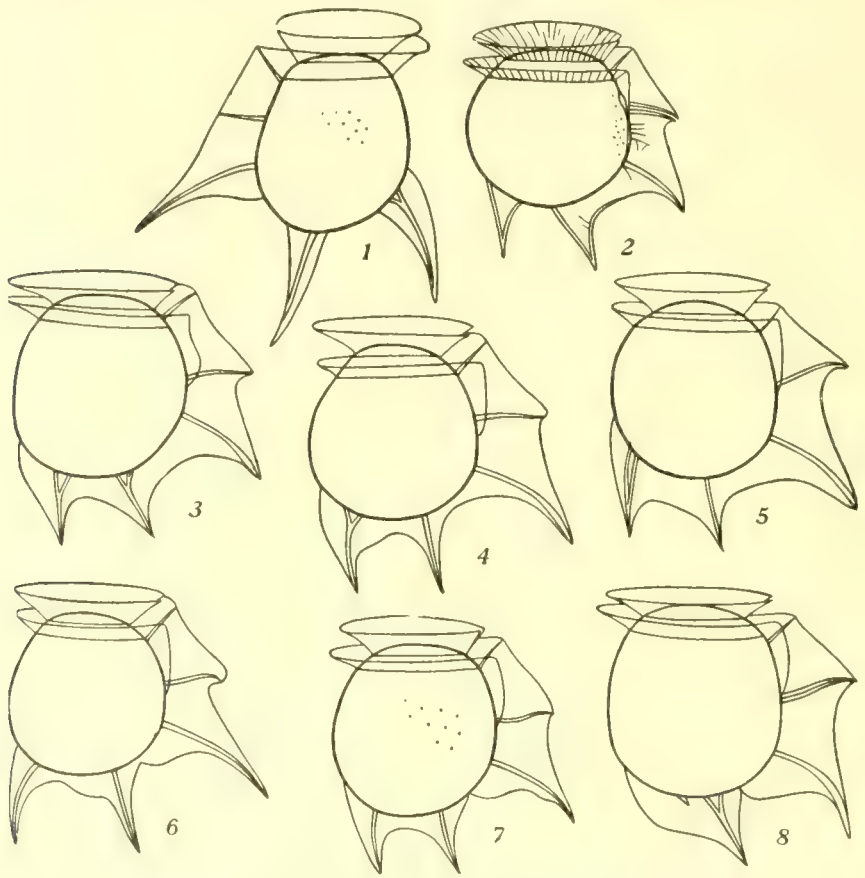

FIGURE 42.— 1, *Dinophysis nias* Karsten, left lateral view; porulation indicated on small portion of thecal wall. × 430. Station 4691 (300–0 fathoms). 2, *Dinophysis triacantha* Kofoid, right lateral view of type specimen. × 430. Station 4722 (300–0 fathoms). 3–8, *Dinophysis jörgenseni*, sp. nov., right lateral view; porulation indicated on small portion of thecal wall in 7. × 430. 3, from Station 4713 (300–0 fathoms); 4, from Station 4609 (300–0 fathoms); 5, from Station 4732 (300–0 fathoms); 6, from Station 4637 (300–0 fathoms); 7, from Station 4709 (300–0 fathoms); 8, from Station 4730 (300–0 fathoms).

Synonymy: — This species was established by Karsten (1907), who described and figured it under the name of *Dinophysis nias*. While his paper was in press, Karsten received Kofoid's (1907a) preliminary report on the dinoflagellates of the Expedition to the Eastern Tropical Pacific. Identifying Kofoid's *D. triacantha* with *D. nias*, Karsten (1907), on page 421 and in the explanation to

Plate 47, wrote the latter name within parenthesis as a synonym of the former. We do not accept this identification but consider these two forms as specifically distinct.

Occurrence: — *Dinophysis nias* is recorded at only one (4691) of the 127 stations, on the third line of the Expedition, in the Easter Island Eddy, from 300–0 fathoms, and at a surface temperature of 73°. The frequency was less than 1% (one specimen).

It was first recorded by Karsten (1907) from the west coast of Sumatra, and probably is widely distributed, but rare, in tropical seas.

Dinophysis jörgenseni, sp. nov.

Plate 5, fig. 3, 7. Figure 42: 3–8, 43

Dinophysis triacantha Jörgensen, 1923, *partim*, p. 34, 43, fig. 47.

Diagnosis: — Body subellipsoidal or subovate in lateral outline, deepest near the middle; length: depth, 0.99–1.08: 1; longitudinal axis perpendicular to girdle or somewhat deflected posterodorsally or posteroventrally. In dorsal view ovate. Anterior cingular list 1.5–2.5 times wider than transverse furrow. Left sulcal list: distance between R_1 and R_3 0.52–0.58 the length of body; R_2 is 0.35–0.43, R_3 is 0.58–0.82 the greatest depth of body; margin often rather strikingly concave just behind R_2 and forms angle of 10°–35° at R_3; R_3 inclined posteriorly at 30°–45° and often club-shaped; usually without accessory structure. With two subequal, acute posterior sails, one on each side of midline, each supported by central rib, which is 0.36–0.55 the greatest depth of body in length and sometimes bifurcate or trifurcate basally; the dorsal usually connected with ventral by list, the minimum width of which is 0.5–1.3 the width of transverse furrow; the ventral usually connected with left sulcal list by similar sail; except for central ribs, posterior sails appear to lack structure. Theca areolate or reticulate. Length, 51.1–58.8 μ.

Widely distributed, but rare, in tropical, subtropical, and warm-temperate seas.

Description: — This is a medium-sized species, the body of which is subellipsoidal to broadly subovate in lateral outline, and deepest in or near the middle. The ratio between the length and the depth of the body is 1.05 (0.99–1.08): 1. The longitudinal axis is sometimes perpendicular to the girdle and sometimes deflected posterodorsally at 3° (1°–15°); seldom it has a slight (1°–3°) posteroventral inclination. The posterodorsal deflection of this axis is unusually

pronounced in the type specimen, viz., 15°; in the other specimens examined it does not exceed 5°.

The epitheca is 0.57 (0.53–0.61) as deep as the hypotheca, highest in or near the center, usually evenly and moderately convex, seldom flat (Plate 5, fig. 7), and not visible above the anterior cingular list. The transverse furrow is flat or slightly convex, and about as wide as or more or less decidedly wider than the greatest height of the epitheca. The posterior cingular list is 0.17 (0.11–0.20) the length of the body from the apex. The hypotheca is sometimes subsymmetrical (Figure 42: 5), sometimes more or less asymmetrical (Plate 5, fig. 7). The dorsal and ventral margins are moderately to rather strongly convex; sometimes they have about the same shape, but either of them may be somewhat more or less convex than the other; in some specimens their convexity is subuniform, in others (Figure 42: 4, 6) they are more or less flattened anteriorly. The postmargin is broadly rounded, sometimes (Plate 5, fig. 7) flattened ventrally, and confluent with the dorsal and ventral margins. The posterior end of the body is either about as deep as the anterior or more or less strikingly deeper. In dorsoventral view the body is ovate, widest somewhat behind the middle, with evenly convex side contours, and with the posterior end somewhat more broadly rounded than the anterior.

The anterior cingular list is 2.1 (1.5–2.5) times wider than the transverse furrow and 0.27 (0.23–0.29) the greatest depth of the body. It has on each valve 14–20 ribs, which usually are simple, straight, and almost equidistant; sometimes some of these ribs are branched (Plate 5, fig. 7) or incomplete (Jörgensen, 1923, fig. 47). The posterior cingular list is either about as wide as or somewhat narrower than the anterior and lacks structural differentiation. Both these lists are funnel-shaped and have an anterior inclination of 30°–40°. The right sulcal list extends to or somewhat beyond the fission rib of the left sulcal list; it is either subtriangular, decreasing gradually in width posteriorly, or of subuniform width throughout the greater portion of its length and more or less well rounded posteriorly; its ventral margin is either straight, gently convex, or sigmoid, concave anteriorly and convex posteriorly. The left sulcal list is large. The distance between the anterior and posterior main ribs is 0.55 (0.52–0.58) the length of the body. The anterior main rib is 0.24 (0.20–0.28), the fission rib 0.40 (0.35–0.43), and the posterior main rib 0.67 (0.58–0.82) the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior main rib and the fission rib the free margin of this list is straight or slightly convex, concave, or sigmoid; between the fission rib and the posterior

main rib it is concave, and the concavity often is rather striking just behind the fission rib. At the posterior main rib this margin forms an angle of 20° (10°–35°); behind this rib it usually is gently to moderately concave, but sometimes it is sigmoid (Figure 42: 6, 8) or somewhat irregular (Figure 42: 7). The main ribs are of moderate strength, and the posterior is often somewhat club-shaped. The anterior main rib is straight or almost so; the fission rib is straight, gently concave posteriorly, or sigmoid (Plate 5, fig. 7); the posterior main rib is gently concave posteriorly. The distance between the anterior main rib and the fission rib is 0.51 (0.48–0.60) the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of 37° (30°–45°). Except for the three main ribs, this list usually lacks structural differentiation, but in some specimens traces of an irregular reticulation may be found; furthermore, in the type specimen (Plate 5, fig. 7) there is an accessory longitudinal rib between the anterior main rib and the fission rib. On the right valve there are two subequal, acute posterior sails, one on each side of the midline, and each supported by a central rib, which may be bifurcate or trifurcate basally and which usually has a gentle ventral concavity. The rib of the ventral of these sails is 0.45 (0.40–0.52), that of the dorsal 0.46 (0.36–0.55) the greatest depth of the body; in other words, these ribs are somewhat shorter than the posterior main rib of the left sulcal list. The angle at the tip of the ventral of these sails is 23° (10°–35°); that at the tip of the dorsal, 25° (10°–40°). In the specimens examined by us the dorsal of these sails is always connected with the ventral by a list, the minimum width of which is 0.5–1.3 the width of the transverse furrow; in the specimen figured by Jörgensen (1923, fig. 47) this connection is broken. The ventroposterior sail usually is connected with the left sulcal list by a list similar to the one between the dorsal and the ventral posterior sails, but this connection too may be broken (Figure 42: 7, 8; Jörgensen, 1923, fig. 47). Except for the central ribs, the posterior sails appear always to lack structural differentiation. There are no parasagittal lists along the dorsal margin of the hypotheca and on the epitheca.

The thecal wall is areolate or reticulate and has scattered pores. The areoles, which are closely set, sometimes are about as small as the pores, and sometimes (Plate 5, fig. 7) they widen into polygonate meshes. The areoles and the polygonate meshes grow fainter toward the margins of the valves, and at least sometimes they are lacking on the epitheca, in the transverse furrow, and along the dorsal, posterior, and ventral margins of the hypotheca (Plate 5, fig. 7). In the transverse furrow two rows of pores are present.

Megacytic stages have not been recorded.

The dimensions of eight of our specimens and of the specimen figured by Jörgensen (1923, fig. 47) were measured.

Dimensions: — Our specimens: Length of body, 51.1–58.8 μ (average, 55.0 μ; type, 54.8 μ). Greatest depth of body, 48.6–56.2 μ (average, 52.7 μ; type, 53.5 μ). The specimen figured by Jörgensen (1923, fig. 47) was about 52.9 μ long and 50.0 μ deep.

Variations: — As conceived in the present paper, this species is rather variable. The most variable characters are as follows: — the shape and structure of the body, the shape of the ventral margin of the left sulcal list, the structure of the central ribs of the two posterior sails, and the development of the lists between the posterior sails and between the ventral posterior sail and the left sulcal list.

Comparisons: — Although fairly variable in several respects, *Dinophysis jörgenseni* is so uniform in size and structure that its systematic unity hardly can be doubted. The allocation of only one of our specimens is questionable. In this specimen (Figure 42: 8) the dorsoposterior sail is indicated only by the bulging of the dorsal margin of the ventroposterior sail and by a rudimentary central rib. Furthermore, the posterior main rib of the left sulcal list of this specimen is more club-shaped and has a more pronounced posterior concavity than in any of the other specimens examined. This specimen is included in the species, since the slight development of the dorsoposterior sail may be due to recent binary fission.

The specimen of this species figured by Jörgensen (1923, fig. 47) differs from our specimens mainly in having no connecting lists between the two posterior sails and between the ventral posterior sail and the left sulcal list. As to the systematic value of this difference, it should be mentioned that in the specimens examined by Jörgensen (1923, p. 34) the posterior sails were either "free, or joined by the sail lists, or the ventral alone connected with the lower part of the large (left) longitudinal list."

The closest-known relatives of *Dinophysis jörgenseni* probably are *D. triacantha* and *D. nias*. This relationship is suggested especially by the presence of two posterior sails. *D. triacantha* is closer to *D. jörgenseni* than is *D. nias* in the shape of its left sulcal list and in having the ventroposterior sail connected with the left sulcal list. It differs most strikingly from *D. jörgenseni* in having the posterior sails supported by marginal instead of by central ribs. *D. nias* approaches *D. jörgenseni* more than does *D. triacantha* in having the posterior sails supported by central ribs, which may be bifurcated basally. It differs from this species especially in having the posterior sails well separated from each other and

from the left sulcal list and in the almost straight ventral margin of its left sulcal list (see also *D. triacantha*, the section on comparisons).

Synonymy: — This species was first described and figured by Jörgensen (1923) under the name of *Dinophysis triacantha* Kofoid. Under this name Jörgensen (1923, p. 35) also included *D. nias* Karsten.

Occurrence: — *Dinophysis jörgenseni* is recorded at twenty-three of the 127 stations. There are 3, 8, 2, 5, 4, and 1 stations on the six lines of the Expedition. Of these stations one (4598) is in the Mexican Current; three (4609, 4613, 4637) are in the Panamic Area; seven (4650, 4651, 4652, 4655, 4659, 4663, 4665) are in the Peruvian Current; two (4713, 4715) are in the Galapagos Eddy; ten (4679,

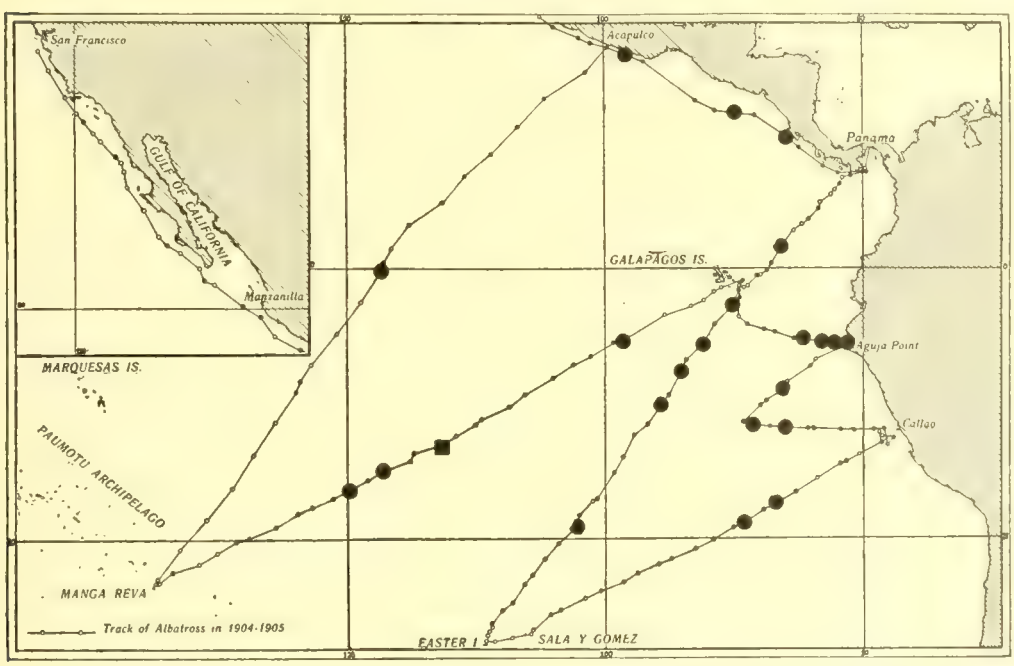

FIGURE 43.— Occurrence of *Dinophysis jörgenseni*, sp. nov. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

4681, 4701, 4709, 4711, 4717, 4727 [type locality], 4730, 4732, 4742) are in the South Equatorial Drift. There is only one record from surface hauls (Station 4727). At one station (4652) the species was taken in a haul from 100–0 fathoms; at one station (4655) in a haul from 400–0 fathoms; and at two stations (4651, 4715) in hauls from 800–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms.

The temperature range of these twenty-three stations at the surface was 65°–84°; the average was 73.3°. At Station 4727, where this species was taken in a surface haul, the surface temperature was 77°.

At three stations (4613, 4663, 4715) the frequency is 1%; at the remaining stations it is less.

This species was first recorded by Jörgensen (1923), who found it at five stations in different regions of the Mediterranean, at one station on the coast of Portugal, and at lat. 3° S., long. 16° W., Gulf of Guinea. In the Mediterranean it seems to occur only below 200 meters (Jörgensen, 1923, p. 35).

This is a eupelagic species, widely distributed, but rare, in tropical, subtropical, and warm-temperate regions. The most outstanding peculiarities about its distribution in the Eastern Pacific, according to our data, are its rare occurrence in surface waters, its absence from the California Current and the northern portion of the Mexican Current, and its relatively frequent occurrence in the Peruvian Current and in the regions under the direct influence of this current. Its optimum habitat probably is in deeper waters, within the levels of photosynthesis.

Dinophysis triacantha Kofoid

Figure 42: 2

Dinophysis triacantha Kofoid, 1907a, p. 196, pl. 12, fig. 74. *non* Karsten, 1907, p. 421, 540, pl. 47, fig. 7. Kofoid & Michener, 1911, p. 292. *non* Jörgensen, 1923, p. 34, 43, fig. 47.

Diagnosis: — Body subcircular in lateral outline; length: depth, 0.97: 1. Both cingular lists ribbed; the anterior 1.5 times wider than transverse furrow. Left sulcal list: distance between R_1 and R_3 0.59 the length of body; R_2 is 0.32, R_3 is 0.48 the greatest depth of body; margin rather strikingly concave just behind R_2 and forms angle of 30° at R_3; R_3 inclined posteriorly at 35°; besides main ribs this list has a few short ribs. With two subequal, acute posterior sails, one on each side of midline, each supported by marginal ribs and lacking central rib; height of these sails, 0.37–0.44 the greatest depth of body; angles at their tips, 20°; no connecting list between posterior sails; ventroposterior sail connected with left sulcal list by list, the minimum width of which is 0.7 the width of transverse furrow; except for marginal ribs, posterior sails lack structure; theca with fine, irregular reticulation. Length, 49.4 μ.

Eastern tropical Pacific.

Description: — This is a medium-sized species, subcircular in lateral outline, and deepest in the middle. The ratio between the length and the depth of the body is 0.97: 1. The longitudinal axis is perpendicular to the girdle.

The epitheca is about 0.58 as deep as the hypotheca, of moderate convexity, highest in the center, and not visible above the anterior cingular list. The trans-

verse furrow is flat or gently concave, and about twice as wide as the greatest height of the epitheca. The posterior cingular list is about 0.21 the length of the body from the apex. The hypotheca has a subcircular outline with almost uniform convexity.

The anterior cingular list is about 1.5 times wider than the transverse furrow and 0.25 the greatest depth of the body; it is inclined anteriorly at 25°–30° and has, on each valve, about 18–20 complete or incomplete ribs, most of which are straight and unbranched. The posterior cingular list is slightly narrower than the anterior, inclined anteriorly at about 25°, and has, on each valve, about 19–20 simple, straight, and almost equidistant ribs. The right sulcal list extends to or slightly beyond the fission rib of the left sulcal list, is subtriangular in shape, decreases gradually in width posteriorly, and is anteriorly about half as wide as the transverse furrow. The left sulcal list is rather large. The distance between the anterior and posterior main ribs is about 0.59 the length of the body. The anterior main rib is about 0.21, the fission rib 0.32, and the posterior main rib 0.48 the greatest depth of the body. Behind the posterior main rib this list decreases suddenly in width. Between the anterior main rib and the fission rib the free margin of this list is straight or almost so; just behind the fission rib it is rather strikingly concave; at the posterior main rib it forms an angle of about 30°; and just behind the last rib it is gently concave. The main ribs are of moderate strength and not club-shaped or otherwise modified. The anterior main rib is straight or almost so; the fission rib and the posterior main rib are gently concave posteriorly. The distance between the anterior main rib and the fission rib is about 0.37 the distance between the anterior and posterior main ribs. The posterior main rib has a posterior inclination of about 35°. Besides the main ribs this list has a few short ribs, some of which may be branched, or a feeble reticulation; at the base of the posterior main rib there is a short posterior branch. On the right valve there are two subequal, acute posterior sails, one on each side of the midline, each supported by marginal ribs and lacking a central rib. The ventral of these sails has a length 0.44 the greatest depth of the body and an angle at the tip of about 20°; the dorsal has a length 0.37 the greatest depth of the body and an angle at the tip of about 20°. There is no connecting list between the posterior sails, but the ventroposterior sail is connected with the left sulcal list by a list, the minimum width of which is about 0.7 the width of the transverse furrow. Except for the marginal ribs, which may have a few short branches, the posterior sails lack ribs. There are no parasagittal lists along the dorsal margin of the hypotheca and on the epitheca.

Megacytic stages have not been recorded.

The dimensions of one specimen only, the type, were measured.

Dimensions: — Length of body, 49.4 μ. Greatest depth of body, 50.7 μ.

Comparisons: — Our description and figure of this species are based on the type specimen.

Dinophysis triacantha appears to be structurally most closely related to *D. nias* and *D. jörgenseni* (see the last two species, the sections on comparisons). It is easily distinguished from these two species by having its two posterior sails supported by marginal ribs instead of by central ribs. The structure of its posterior sails is suggestive of a fairly close affiliation to *D. uracantha*, *D. urceolus*, *D. monacantha*, and *D. trapezium*, but this must be regarded as uncertain.

Synonymy: — The species was established by Kofoid (1907a), who described and figured it under the name of *Dinophysis triacantha*. *D. triacantha* Karsten (1907) is identical with *D. nias* Karsten and not with *D. triacantha* Kofoid. *D. triacantha* Jörgensen (1923) refers both to *D. nias* Karsten and to *D. jörgenseni* nobis.

Occurrence: — *Dinophysis triacantha* is recorded at only one (4722, type locality) of the 127 stations, on the fifth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, and at a surface temperature of 75°. The frequency is less than 1% (one specimen).

3. Caudata Group.— *Dinophysis caudata*, *D. tripos*, and *D. miles* belong to this group. Of these only the first was found in the material of the Expedition.

Dinophysis caudata Saville-Kent

Figure 44, 45

Dinophysis caudata Saville-Kent, 1881, p. 455, 460. Jörgensen, 1923, p. 22, 24–30, 43–45. Pavillard, 1923a, p. 881.

Dinophysis acuta var. *geminata* Pouchet, 1883, p. 27, pl. 18, 19, fig. 5.

Dinophysis homunculus Stein, 1883, *partim*, p. 3, 24, pl. 21, fig. 1, 2, 5–7. Bergh, 1884, p. 385. Bütschli, 1885, p. 995, 996, pl. 55, fig. 36. Imhof, 1886, p. 102. Hensen, 1887, p. 77, tab. 13–16; 1911, p. 164, 165. Möbius, 1887, p. 121. Daday, 1888, p. 99. Whitelegge, 1891, *partim*, p. 184, pl. 28, fig. 14. Walther, 1893, p. 129. Schütt, 1895, p. 65, 112, pl. 2, fig. 8. Cleve, 1897a, p. 26, tab. 1; 1899a, p. 17; 1899c, p. 4; 1900b, p. 1031; 1900e, p. 21, 35, 39; 1900f, p. 925, 936; 1901a, p. 15; 1901c, p. 239; 1902a, p. 10, 25; 1902b, p. 29; 1903a, p. 38; 1903b, p. 344. Ostenfeld, 1898a, p. 428; 1898b, tab. 3–5; 1899, tab. 2–5; 1902, p. 20; 1906, p. 18; 1915, p. 6; 1916b, p. 13. Lemmermann, 1899a, p. 319, 373; 1901a, p. 374; 1902a, p. 263; 1905a, p. 36. Minkiewitsch, 1899, p. 357, 361. Murray & Whitting, 1899, p. 331, tab. 1, 3–6, 8, 9. Schröder, 1900a, *partim*, p. 19, 21, 35; 1900b, p. 3; 1906a, p. 321, 325, 326, 374; 1906b, p. 262; 1909, p. 211; 1911, p. 12, 17, 18, 25, 36, 37, fig. 7b. Schmidt, 1901, p. 138. Ostenfeld & Schmidt, 1901, p. 169. Cleve, Ekman & Pettersson, 1901, p. 36. Gran, 1902, p. 184. Lohmann, 1902, p. 53; 1908a, p. 168, 169. Entz, 1902a, fig. 1; 1902b, p. 94; 1905, p. 111; 1907, p. 19; 1909, p. 255. Paulsen, 1904, p. 29; 1908, p. 12, 19, fig. 20; 1912, p. 290. Pavillard, 1905, p. 59, 100, 102; 1909, p. 284; 1916, p. 56, fig. 15A. Karsten, 1905, p. 8, 34, 35; 1906, p. 180,

183, 193, 195, 196, 198, 205–207, 210–213, 215, 217, 218; 1907, p. 225, 240, 269, 278, 332, 333, 335, 359, 424, 445, 449, 451, 471, 472. Apstein, 1905a, tab. 2, 10. Clark, 1905, p. 179, 182, 188. Jörgensen, 1905, p. 50, 108; 1923, p. 24, 29. Zacharias, 1906, p. 509, 530, 531, 533, 534, 536, 538, 540, 544, 545, 549, 551, 552, 554. Linko, 1907, p. 109, 111. Nathansohn, 1908, p. 604, 612; 1909, p. 46, 59; 1910a, p. 14, 15, 20. Czapek, 1909, p. 8, fig. 5. Stüwe, 1909, p. 243, 254, 288. Gräf, 1909, p. 139, 157, 159, 161, 163, 171, 173, 184, 192. Reinhard, 1910, p. 8, 12, 14, 15, 16, 23, 26. Schiller, 1911a, p. 52; 1911b, p. 90; 1912, p. 27. Carazzi & Grandori, 1912, p. 48, tab. F. Mangin, 1912, p. 5–7, 10, 12–18, 20, 21, 58, 60, tab. 2. Faria & Cunha, 1917, p. 74. Cunha & Fonseca, 1917, p. 141. Forti, 1922, p. 107, 109, 190, 208, fig. 114.

Dinophysis allieri Gourret, 1883, p. 75, 76, 78–80, pl. 3, fig. 54, 54a.

Dinophysis inaequalis Gourret, 1883, p. 77, 78, 80, pl. 1, fig. 21.

Dinophysis homunculus and *caudata* Grenfell, 1887, p. 559.

Dinophysis semicarinata Grenfell, 1887, p. 560, pl. 11, fig. 12.

Dinophysis homunculus f. *pedunculata* Schmidt, 1901, p. 138, fig. 8. Okamura, 1907, p. 131, fig. 40; 1912, p. 19. van Oye, 1921, p. 215.

Dinophysis homunculus var. *carinata* Zacharias, 1906, p. 540.

Dinophysis homunculus var. *pedunculata* Schröder, 1906a, p. 335. Jörgensen, 1923, p. 25, 29.

Dinophysis homunculus var. *gracilis* Schröder, 1911, p. 5, 7, 22–24, 36, fig. 7a.

Dinophysis geminata Kofoid & Rigden, 1912a, p. 337.

Dinophysis pedunculata Ostenfeld, 1915, p. 6, 7.

Dinophysis caudata var. *allieri* Jörgensen, 1923, p. 25.

Dinophysis caudata allieri f. *speciosa* Jörgensen, 1923, p. 25, fig. 30.

Dinophysis caudata var. *abbreviata* Jörgensen, 1923, p. 25, 27, 28, fig. 31.

Dinophysis caudata f. *marmarae* Jörgensen, 1923, p. 26, 45, fig. 33.

Dinophysis caudata f. *pontica* Jörgensen, 1923, p. 26, 45, fig. 34.

Dinophysis homunculus var. *latus* Lindemann, 1923, p. 220, fig. 11, 12; 1925, p. 101.

Diagnosis: — Body very variable in shape, elongated; deepest somewhat in front of to somewhat behind the middle, and 1.65–3.23 times longer than deep; anterior portion irregularly obovate in lateral outline, subtruncate anteriorly; posterior portion more or less slender, pedunculate, of varying length; transition between anterior and posterior portions gradual or more or less sudden; longitudinal axis inclined posteroventrally at 7°–30°. In dorsal view strongly flattened, 7–8 times longer than wide. Anterior cingular list 1.5–2.5 as wide as transverse furrow. Left sulcal list extends to base of peduncle; distance between R_1 and R_3 0.28–0.38 the length of body; R_2 is 0.23–0.59, R_3 is 0.31–0.77 the greatest depth of body; margin forms angle of 70°–110° at R_3, or this portion of list is recurved; R_3 about parallel to girdle; with more or less developed reticulation. Theca finely and closely areolate. Length, 71.8–107.0 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas, seldom in colder waters.

Description: — This is a medium-sized to rather large species, very variable in shape, elongated, and deepest somewhat in front of to somewhat behind the middle. The anterior portion of the body is irregularly obovate in lateral outline, subtruncate anteriorly; the posterior portion is more or less slender, pedunculate, of varying length. The ratio between the length and the depth of the body is 1.65–3.23: 1; in our specimens this ratio is 2.06 (1.65–2.46): 1; in the specimens

figured by Stein (1883, pl. 21, fig. 1, 2, 5) which are unusually slender, it is 2.82–3.23: 1. The longitudinal axis is inclined posteroventrally at 7°–30°; in our specimen this angle measured 20° (14°–30°). Seldom almost symmetrical specimens are found (see Stein, 1883, pl. 21, fig. 1, and Jörgensen, 1923, p. 25).

The epitheca is gently convex to very slightly concave, highest in the middle or near the dorsal side, not visible above the anterior cingular list, and 0.43–0.58 as deep as the hypotheca; in our specimens this ratio is 0.51(0.45–0.58): 1; in Stein's (1883) it is 0.43–0.46: 1. The transverse furrow is flat or gently concave, and generally somewhat wider than the greatest height of the epitheca. The posterior cingular list is 0.04–0.08 the length of the body from the apex. The hypotheca is very variable in shape; its anterior portion is irregularly obovate, and its posterior portion is more or less slender, pedunculate. The transition between the anterior portion and the posterior (the peduncle) sometimes is gradual, sometimes more or less sudden; in forma *pedunculata* it is very sudden. The ratio between the length of the body and that of the peduncle is variable, due to the great variability of the length of the peduncle. In our specimens this ratio is 2.73 (2.35–4.21): 1; in the specimens figured by Stein (1883) it is 2.21–2.50: 1; in the other specimens of this species figured by previous authors it falls within this range of variation. The dorsal margin of the anterior portion of the hypotheca either is gently concave (Stein, 1883, pl. 21, fig. 2, 5), straight (Stein, 1883, pl. 21, fig. 1), almost uniformly and gently to moderately convex (Figure 44: 2), or its anterior and posterior parts are gently convex or almost straight and together form a broadly rounded but distinct corner (Figure 44: 4); this corner has a varying relative position (Figure 44: 5, 6), but usually it is located behind the middle of this margin. The ventral margin of the anterior portion of the hypotheca usually is straight or almost so, or it is gently undulating, being convex anteriorly and posteriorly and concave in the middle. Proximally the peduncle is 0.30–0.55 the greatest depth of the body and about 1.9–3.0 times wider than distally. In most specimens its dorsal and ventral margins are gently convex, but sometimes they are almost straight (Figure 44: 6) or somewhat irregular (Figure 44: 7). Posteriorly the peduncle is truncate, rounded, or pointed; when truncate or rounded, the antapex frequently has one to four tubercles of varying size. In dorsoventral view the body is very narrow, about seven to eight times longer than wide (Stein, 1883, pl. 21, fig. 6, 7), and with subparallel sides.

The cingular lists may be subequal, but in most specimens the posterior is somewhat narrower than the anterior; the anterior is 1.5–2.5 times wider than the transverse furrow and 0.26 (0.18–0.35) the greatest depth of the body; both are

funnel-shaped, with an anterior inclination of 20°–50°; sometimes the posterior is somewhat less inclined than the anterior. In most cases the anterior has, on each valve, about ten to fifteen simple, straight, almost equidistant, and sometimes partly incomplete ribs; sometimes the posterior may have about the same structure as the anterior, but in most specimens it lacks structural differentiation. The right sulcal list ends from just in front of to somewhat behind the fission rib of the left sulcal list; it either is subtriangular, decreasing gradually in width posteriorly, or it is of subuniform width throughout its anterior half; anteriorly it is about as wide as, or usually somewhat wider than, the transverse furrow. The left sulcal list extends to the base of the peduncle; the distance between the anterior and posterior main ribs is 0.33–0.42 the length of the body. In our specimens the anterior main rib is 0.29 (0.21–0.40), the fission rib 0.32 (0.23–0.40), and the posterior main rib 0.40 (0.31–0.50) the greatest depth of the body. In the specimens figured by Stein (1883, pl. 21, fig. 1, 2, 5) this list is unusually wide and the corresponding values are 0.40 (0.34–0.50), 0.48 (0.44–0.59), and 0.66 (0.59–0.77). Behind the posterior main rib this list decreases suddenly in width. Between the anterior and posterior main ribs the free margin of this list is gently concave (Figure 44: 6), almost straight throughout (Figure 44: 3), almost straight anteriorly and posteriorly and convex in the middle (Jörgensen, 1923, fig. 34), gently to moderately convex (Figure 44: 2), or gently sigmoid, straight to gently concave anteriorly and convex posteriorly (Figure 44: 7). At the posterior main rib this margin forms an angle of 70°–110°; or this portion of the list is more or less strikingly recurved (Stein, 1883, pl. 21, fig. 1; Jörgensen, 1923, fig. 31). Behind the posterior main rib this margin either is almost straight, somewhat convex or irregular (Figure 44: 1), or it is more or less concave (Jörgensen, 1923, fig. 31). The main ribs of this list are of moderate strength; the two anterior are straight or almost so; the posterior, which in exceptional cases (Stein, 1883, pl. 21, fig. 5) is club-shaped, is sometimes straight but generally more or less concave posteriorly. The distance between the anterior main rib and the fission rib is 0.40–0.55 the distance between the anterior and posterior main ribs. The posterior main rib is about parallel to the girdle. In some specimens the whole list has a well-developed reticulation, in others the reticulation is more or less reduced or even totally absent. There are no accessory lists or sails.

The thecal wall is areolate. The areoles are usually numerous and rather small (Figure 44: 4), but their size and number are somewhat variable (Stein, 1883, pl. 21, fig. 1, 2, 5).

Megacytic stages have not been recorded.

The species is characterized by the fact that after binary fission the two schizonts remain for some time attached to each other by a ridge along the posterior portion of the dorsal margin of the anterior part of the hypotheca. This ridge sometimes is rather narrow (Figure 44: 6), sometimes it is rather wide (Figure 44: 2); in some specimens it is without structural differentiation; in others it is areolate.

The dimensions of ten of our specimens and of the specimens figured by previous investigators were measured.

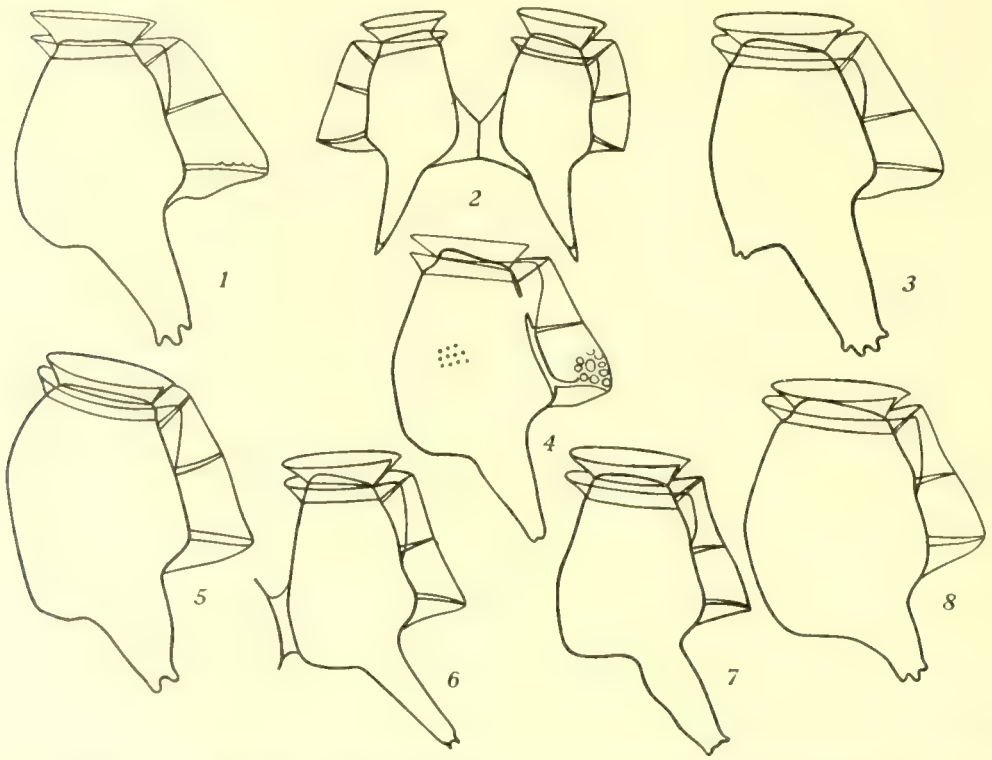

FIGURE 44. — *Dinophysis caudata* Saville-Kent, right lateral view, structure of thecal wall and of left sulcal list indicated only in 4. 2, two schizonts, not yet detached from each other. 6, two schizonts, one of which is indicated only by a portion of its dorsal margin. × 430. 1, 3, from Station 4637 (300–0 fathoms); 2, from Station 4594 (300–0 fathoms); 4, from Station 4571, surface; 5, 8, from Station 4652 (300–0 fathoms); 6, 7, from Panama Harbor, surface.

Dimensions: — Our specimens: Length of body, 71.8–107.0 μ (average, 94.3 μ). Greatest depth of body, 29.2–56.5 μ (average, 46.5 μ). The specimens figured at known magnifications by previous investigators fall within the range of variation given above for our specimens. The figures of this species given by Stein (1883, pl. 21, fig. 1, 2, 5) are of unknown magnifications. Judging by Stein's (1883) information about the magnifications of his figures, given in an intro-

ductory remark to the explanations of the plates, the length of the largest of his specimens (pl. 21, fig. 1) was somewhere between 132 μ and 201 μ.

Variations: — As conceived in the present paper, this species is almost protean. Previous authors have subdivided it into a number of forms, varieties, or even species, but this subdivision is based on rather limited material and inadequate knowledge of the species, and not on extensive biological and statistical investigations. The systematic value of these "forms," "varieties," and "species" is therefore not known as yet. Future investigators with adequate material at their disposal may be able to show that at least some of these units are the expressions of genetic processes. On the other hand, it is probable that many if not all of them are modifications, due to changes in the surrounding medium, to regulatory processes consequent upon binary fission, or to metabolic phenomena, *e.g.*, the ratio between the rate of growth of the protoplasm and the rapidity of fission.

It should be noted that in the inner region of the Aegean Sea, in the Marmora Sea, and in the Black Sea, where the salinity is low in comparison with that of the open Mediterranean, as well as in the brackish Porkljan Lake on the Dalmatian coast, this species is represented by more or less aberrant forms (Jörgensen, 1923, p. 26; Schröder, 1911, p. 36).

With regard to the possible connection between some differences in the shape and size of the body and binary fission, a "degenerate" specimen of this species figured by Jörgensen (1923, fig. 37) may be significant. This specimen evidently was taken shortly after the separation of the two schizonts in binary fission. Its right (old) valve shows a striking resemblance to Pavillard's (1916, fig. 15B) *Dinophysis homunculus* var. *ventricosa* (= *caudata* var. *acutiformis*). Its left (new) valve, on the other hand, is decidedly smaller than the right and has a shape which is very similar to that of *D. caudata* var. *subdiegensis* Jörgensen (1923, fig. 35). If in this specimen the next fission had taken place before the new valve had reached the size of the old (supposing that such a postfission increase in size does take place, which is not known), one of the daughter individuals probably would have been referable to *D. caudata* var. *acutiformis*, the other to *D. caudata* var. *subdiegensis*. The smallness of the left (new) valve of this specimen probably was due to a disproportion between the rate of growth of the protoplasm and the rapidity of fission. This supposed disproportion might have been brought about either by an increased rate of fission not accompanied by a correspondingly increased growth of the protoplasm, or by a decrease in the growth of the protoplasm without a proportionally low rate of fission. In the latter case we would be

dealing with a case of degeneration, possibly called forth by adverse hydrographical conditions. It should be remembered in this connection that specimens of *D. caudata* var. *acutiformis* and var. *subdiegensis* never have been recorded except from near the coast line, where the hydrographical conditions are more or less changeable and different from those of the open sea. We should also remember "the exceedingly great sensitiveness of pelagic organisms to even slight changes in their environment" (Kofoid, 1909, p. 245).

On the other hand, the specimen mentioned above may be comparable to the heteromorphic chains found in the genus Ceratium by Lohmann (1908) and Kofoid (1909), an assumption that has already been voiced by Jörgensen (1923, p. 29). About the systematic significance and possible causes of such chains, see Kofoid (1909) and Jörgensen (1911).

A third possibility is that fission was completed before the regulatory formation of the new half of the theca was accomplished, and that this would have later ensued, restoring the organism to the ancestral form.

The value of this specimen as evidence in the problem of the variability of this species is therefore rather uncertain. Compare also the lengths of the peduncles in the two schizonts from Karrachee represented by Czapek (1909, fig. 5).

Under these circumstances it has been considered advisable in the present paper to treat most of the above-mentioned "forms," "variations," and "species" under the name of *Dinophysis caudata*, and, with one exception, not to assign the specimens found in the material of the Expedition and considered to belong to this species, to any one of these smaller units.

The following characters are more or less strikingly variable in this species, as conceived in the present paper: — the size of the body, the inclination of the longitudinal axis of the body, the depth and the shape of the anterior portion of the body, the width, shape, and size of the peduncle, *i.e.*, the posterior portion of the body, the tuberculation of the antapical end of the body, and the width, shape, and structure of the left sulcal list.

According to the conception of *Dinophysis caudata* adopted in the present paper and by Jörgensen (1923, p. 25), the specimen represented by Jörgensen's (1923) figure 30 under the name of *D. caudata* Kent α *allieri* (Gourret) f. *speciosa* Jörgensen may be considered as typical of this species. Kent's (1881, p. 460) original description of *D. caudata* is very fragmentary and is not accompanied by any illustrations. It does not suffice for a perfectly certain determination of species, but it conforms fairly well with the mentioned figure of Jörgensen (1923).

This form may be characterized briefly in the following way: — the body is slender, and its longitudinal axis is somewhat inclined posteroventrally; the transition between the anterior portion of the body and the peduncle is rather gradual than sudden; the peduncle is rather long, and attains about the length of the left sulcal list; the left sulcal list is broad, and decidedly broader posteriorly than anteriorly. None of the specimens of this species found in the material of the Expedition agrees completely with this form, and, as far as our records go, only one of them (Figure 44: 2) approaches it rather closely.

The great majority of our specimens (Figure 44: 4) resemble very closely the specimen from Japanese waters figured by Okamura (1907, fig. 40a) under the name of *Dinophysis homunculus* f. *pedunculata*. In other words, they have a habitus which in several respects is intermediate between Grenfell's (1887) *D. semicarinata* and Schmidt's (1901) *D. caudata* f. *pedunculata*. This form may be given the following short characterization: — the body is somewhat less slender than in the typical form of this species, and its longitudinal axis is somewhat inclined posteroventrally; the transition between the anterior portion of the body and the peduncle is rather sudden than gradual, but not quite so sudden as in Schmidt's (1901) *D. caudata* f. *pedunculata*; the peduncle is of moderate length, being somewhat shorter than the left sulcal list; the left sulcal list is rather broad, and somewhat broader posteriorly than anteriorly.

Some of our specimens (Figure 44: 7) show a still more pronounced resemblance to *Dinophysis caudata* f. *pedunculata* Schmidt than those mentioned in the last paragraph. Indeed, the agreement sometimes was almost complete.

As far as our records go, the form represented by Figure 44: 3 was found but once in the material of the Expedition. It is easily distinguished from the typical form of this species by the rather sudden transition between the anterior portion of the body and the peduncle, by the rather broad, tuberculate peduncle, and by the two tubercles on the dorsal protuberance of the body just in front of the peduncle. In the last character this form approaches *Dinophysis tripos*, a form which in the present paper is considered as specifically distinct from *D. caudata*, and which never was found in the material of the Expedition.

Some of our specimens of this species (Figure 44: 5, 8) differed rather strikingly from the forms discussed above, and in several respects approached the forms figured by Jörgensen (1923, fig. 33, 34) under the names of *Dinophysis caudata* f. *marmarae* and *D. caudata* f. *pontica*. These specimens may be briefly characterized as follows: — the longitudinal axis of the body is somewhat inclined posteroventrally; the anterior portion of the body is deep and bulky, and

its transition to the peduncle is sometimes rather sudden, sometimes more or less gradual; the peduncle is more or less reduced in size, in some cases being only about half as long as the left sulcal list; the left sulcal list is rather broad.

In the material of the Expedition we also have found specimens which to varying extents are intermediate between the form (Figure 44: 4) to which belongs the majority of our specimens of this species on the one hand, and (Figure 44: 3) the form approaching *Dinophysis tripos* and the forms treated in the last paragraph. (See also *D. caudata* f. *acutiformis*, the section on comparisons, and Jörgensen, 1923, p. 24–27.)

Comparisons: — *Dinophysis tripos* is the structurally closest-known relative of *D. caudata*. Indeed, transitional specimens between these two forms have been found (Figure 44: 3), and even their specific separation has been questioned; see the section on synonymy. *D. tripos* is a connecting link, presumably genetically as well as morphologically, between *D. caudata* and *D. miles*. The last species occurs in at least two rather different varieties (whether or not specifically distinct is unknown), viz., *D. miles miles* (Cleve, 1900b, fig. 1a) and *D. miles* f. *schröteri* (Forti) Ostenfeld. (A third variety, established by Schröder, 1906a, under the name *D. miles* f. *maris jonii*, has not been figured or sufficiently described and thus cannot be considered in this connection.) Of these two varieties the former is less excessively differentiated and therefore presumably more closely related to *D. caudata* than the latter. *D. caudata* differs from *D. tripos* and *D. miles* in not having a well-developed dorsal process just in front of the peduncle.

The three species mentioned in the last paragraph occupy a rather isolated position, and we do not know which of the remaining species of Dinophysis are their closest relatives. See also the section on variations and *D. caudata* f. *acutiformis*, the section on comparisons.

Synonymy: — This species, as conceived in the present paper, has appeared under several different names, which will be discussed briefly in the following paragraphs.

It was first described by Saville-Kent (1881), and later described and figured by Jörgensen (1923) under the name of *Dinophysis caudata*. These investigators, besides Grenfell (1887, p. 559, 560), are the only ones who have used this name.

The first author, after Saville-Kent (1881), to treat this species is Pouchet (1883, p. 27, pl. 18–19, fig. 5; 1885a, p. 22), who, under the name of *Dinophysis acuta* var. *geminata*, figured two schizonts not yet detached from each other. The similarity between these two specimens and *D. caudata* α *allieri* f. *speciosa* Jörgensen (1923, fig. 30), *i.e.*, the typical form of *D. caudata*, is very striking. *D. acuta*

var. *geminata* is regarded as identical with *D. caudata* by Bergh (1884, p. 385), Bütschli (1885, p. 995), Paulsen (1908, p. 19), and Jörgensen (1923, p. 24). Lemmermann (1899a, p. 373) identified it with *D. allieri* Gourret (see below). Kofoid and Rigden (1912a, p. 337) use the name *D. geminata* without discussing the systematic position of this form.

Shortly after the publication of Pouchet's (1883) work, referred to in the last paragraph, *Dinophysis caudata* was excellently figured in Stein's (1883, pl. 21, fig. 1, 2, 5, 6, 7) big iconography under the name of *D. homunculus*. The name last-mentioned was accepted for this species by almost everybody, and the two older names were forgotten or disregarded. Under the name of *D. homunculus* this species was later figured or described by the following authors: — Whitelegge (1891, p. 184, pl. 28, fig. 14), Schütt (1895, p. 65, 112, pl. 2, fig. 8), Entz (1902a, fig. 1), Czapek (1909, fig. 5), Schröder (1911, p. 36, fig. 7b), and Pavillard (1916, p. 56, fig. 15a). Bütschli (1885, p. 995, 996, pl. 55, fig. 36) reproduces Stein's (1883) Plate 21, figure 1; Paulsen (1908, p. 19, fig. 20) reproduces Stein's (1883) Plate 21, figure 2; and Forti (1922, fig. 114) reproduces Pavillard's (1916) figure 15a.

Almost simultaneously with the publication of Stein's (1883) iconography, Gourret (1883) issued a paper in which were established three species belonging to the genus Dinophysis, viz., *D. allieri*, *D. inaequalis*, and *D. tripos*.

There seems to be but little doubt that *Dinophysis allieri* and *D. inaequalis* should be referred to *D. caudata*. Indeed, *D. allieri* probably represents the typical form of this species; see Jörgensen (1923, p. 25). *D. allieri* Gourret (1883, p. 75, 76, 78, 79, 80, pl. 3, fig. 54, 54a) is considered as identical with *D. caudata* by Whitelegge (1891, p. 185), Schröder (1900a, p. 19), Pavillard (1905, p. 59), Paulsen (1908, p. 19), Okamura (1912, p. 19), Faria and Cunha (1917, p. 74), and Forti (1922, p. 108). Bergh (1884, p. 385), Lemmermann (1899a, p. 373), and Jörgensen (1923, p. 24, 25, fig. 30) treat it as a variety of *D. caudata*. *D. inaequalis* Gourret (1883, p. 77, 78, 80, pl. 1, fig. 21) is regarded as identical with *D. caudata* by Whitelegge (1891, p. 185), Pavillard (1905, p. 59), Paulsen (1908, p. 19), Okamura (1912, p. 19), Faria and Cunha (1917, p. 74), and Jörgensen (1923, p. 24, 25). Bergh (1884, p. 385) regards it as a variety of *D. caudata*. Schröder (1900a, p. 19) is doubtful about its systematic status.

The systematic position of *Dinophysis tripos* Gourret (1883, p. 76, 80, pl. 3, fig. 53) must be regarded as unsettled. This form is treated as a variety of *D. caudata* by Bergh (1884, p. 385), Lemmermann (1899a, p. 373; 1901a, p. 374; 1905a, p. 36), Ostenfeld and Schmidt (1901, p. 170), Entz (1902b, p. 94; 1905,

p. 112), Schröder (1906a, p. 322, 340), and Lebour (1917a, tab. 1; 1917b, p. 184). Paulsen (1908, p. 19) and Okamura (1912, p. 19) suggest that *D. tripos* and *D. caudata* may be identical, and Stein (1883, pl. 21, fig. 3, 4) does not separate them systematically. Some of the authors mentioned in this paragraph change their attitude in this question and treat *D. tripos* as a distinct species; these authors are: Ostenfeld (1906, p. 18; 1909, p. 23; 1915, p. 6; 1916, p. 13), Schröder (1911, p. 25), and Paulsen (1912, p. 290). Other investigators who treat *D. tripos* as a distinct species are: Pavillard (1905, p. 59; 1909, p. 284; 1916, p. 57), Gough (1907, p. 190, 192), Gräf (1909, p. 155), Hensen (1911, p. 165), Schiller (1912, p. 27), Faria and Cunha (1917, p. 74), Forti (1922, p. 109), and Jörgensen (1923, p. 29, 30, fig. 38, 39). Pavillard (1909, p. 283) writes that the comparison of a great number of specimens collected during all seasons of the year "me permet de considérer comme nécessaire la séparation définitive de *D. Homunculus* Stein et *D. tripos* Gourret." Jörgensen (1923, p. 31) calls *D. tripos:* "this easily recognizable and very constant species." In the material of the Expedition a specimen (Figure 44: 3) was found which approached *D. tripos* f. *brevicauda* Jörgensen (1923, fig. 39) in the structure of the dorsal projection at the base of the peduncle, and which, on the other hand, showed a great similarity to some of the specimens (Figure 44 1) which in the present paper have been referred to *D. caudata.* In other words, specimens do exist which are more or less intermediate between *D. tripos* and *D. caudata*, as conceived in the present paper. Compare also Figure 40a and 40b, Plate 5, Okamura (1907). However, the evidence seems to be in favor of the opinion of those who regard *D. tripos* as a distinct species. The names of this form, therefore, have not been included in our bibliographical list of *D. caudata.*

Dinophysis homunculus var. *appendiculata* Zacharias (1906, p. 538, 540, 574) is a synonym of *D. tripos* (see Faria and Cunha, 1917, p. 74, and Jörgensen, 1923, p. 29).

Dinophysis homunculus var. *incurva* is a name applied by Lemmermann (1899a, p. 373) to the two specimens of *D. tripos* figured by Stein (1883, pl. 21, fig. 3, 4); see Jörgensen (1923, p. 30).

In this connection it may be mentioned that Whitelegge (1891, p. 185) supposed that "*D. homunculus* is identical with *D. inaequalis* Gourret, and *D. allieri* Gourret, and that all three are simply immature forms of *D. tripos* Gourret." This statement is explained by the fact that this investigator has confused the phylogenetic and the ontogenetic processes in the genus Dinophysis.

Dinophysis semicarinata Grenfell (1887, p. 560, pl. 11, fig. 12) agrees closely with *D. caudata* f. *pontica* Jörgensen (1923, fig. 34). It is mentioned only by Jör-

gensen (1923, p. 24), and should preliminarily be referred to *D. caudata* (see the section on the variations of this species).

The systematic status of *Dinophysis homunculus* f. *pedunculata* Schmidt (1901, p. 138, fig. 8) is somewhat doubtful. Lemmermann (1901a, p. 374), Schröder (1906a, p. 335), Okamura (1907, p. 131, pl. 5, fig. 40; 1912, p. 19), van Oye (1921, p. 215), and Jörgensen (1923, p. 25, 29) consider this form as a variety of *D. caudata*. Ostenfeld (1915, p. 6), on the other hand, writes that it "no doubt" is an independent species. The fact that this form seems to have a geographical distribution different from that of the other forms of *D. caudata* indicates that it is different genetically. It was first recorded by Schmidt (1901) from the Gulf of Siam; later van Oye (1921) reported it from Batavia, Java; Ostenfeld (1915) from the coast of Celebes; Schröder (1906a) from the Formosa Straits; and Okamura (1907, 1912) from Japanese waters. Jörgensen (1923, p. 29) found it on the coast of Arabia, and some of the specimens recorded by Whitelegge (1891) from Sydney, Australia, under the name of *D. homunculus*, probably belong to this form. The great majority of the specimens of *D. caudata* found in the material of the Expedition also belong to this form. However, in spite of its peculiar distribution, it seems most advisable to refer *D. pedunculata* to *D. caudata* until further evidence is available. See also the section on the variations.

Dinophysis homunculus var. *carinata* Zacharias (1906, p. 540) undoubtedly refers to a recently divided specimen of *D. caudata* in which the fission ridge on the dorsal side of the body has not yet been absorbed.

The two specimens figured from the Golden Horn and the Bosporus by Lindemann (1923, p. 220, fig. 11, 12) under the name of *Dinophysis homunculus* var. *latus* are referable to *D. caudata* f. *marmarae* and *D. caudata* f. *pontica*, respectively, figured by Jörgensen (1923) from the same waters.

The reader is referred to the section on the variations of this species for our reasons for including in the bibliographical list of *Dinophysis caudata* the following names: — Schröder's (1911) *D. homunculus* var. *gracilis* (also mentioned by Jörgensen, 1923, p. 27) and Jörgensen's (1923) *D. caudata* var. *allieri*, *D. caudata* var. *abbreviata*; *D. caudata* f. *marmarae*, and *D. caudata* f. *pontica*.

Under *Dinophysis caudata* f. *acutiformis* will be discussed the systematic status and synonymy of the following forms belonging to or at any rate close relatives of *D. caudata:* — *D. diegensis* Kofoid and its varieties *curvata* Kofoid and *caudata* Pavillard, *D. homunculus* var. *ventricosa* Pavillard, and *D. caudata* var. *subdiegensis* Jörgensen (= *D. kofoidi* Jörgensen).

Reinhard (1910, p. 26) wrote *Dinophysis homumnculus* for *D. homunculus*.

Hensen (1911, p. 164, tab. 15) used *D. hormunculus* and *D. hornunculus* for *D. homunculus.*

Occurrence: — *Dinophysis caudata* is recorded at fifty of the 127 stations. There are 16, 23, 3, 5, 0, and 3 stations on the six lines of the Expedition. Of these fifty stations, four (4571, 4574, 4580, 4583) are in the California Current; nine (4588, 4594, 4596, 4598, 4600, 4604, 4605, 4545, 4546) are in the Mexican Current; twelve (4609, 4611, 4613, 4615, 4617, 4631, 4634, 4637, 4638, 4639, 4640, 4644) are in the Panamic Area; nineteen (4647, 4649, 4650, 4651, 4652, 4655, 4657, 4659, 4660, 4663, 4666, 4667, 4668, 4669, 4670, 4671, 4675, 4676,

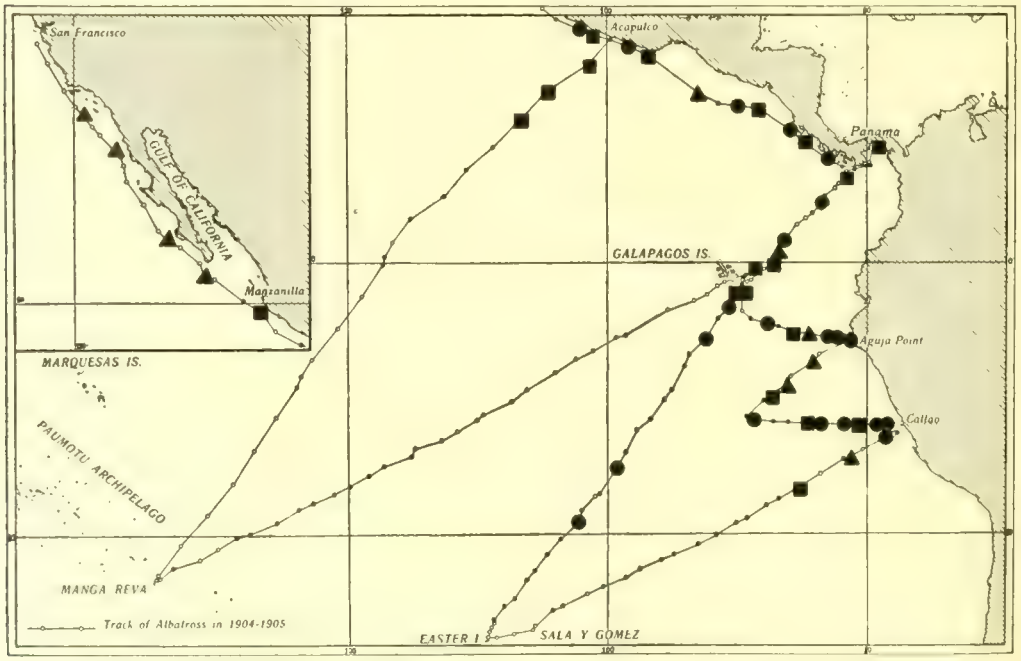

FIGURE 45.— Occurrence of *Dinophysis caudata* Saville-Kent. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

4678) are in the Peruvian Current; two (4701, 4705) are in the South Equatorial Drift; three (4713, 4715, 4716) are in the Galapagos Eddy; one (4544) is in the North Equatorial Current. There are twenty-eight records from the surface (Stations 4571, 4574, 4580, 4583, 4588, 4596, 4600, 4604, 4611, 4615, 4631, 4638, 4639, 4640, 4644, 4649, 4650, 4657, 4659, 4660 [Salpa], 4666, 4669, 4676, 4678, 4716, 4544, 4545, 4546); at eight of these stations (4571, 4574, 4580, 4583, 4638, 4650, 4657, 4659) the species was taken in hauls from 300–0 fathoms as well as at the surface; and at one station (4676) it was taken in hauls from 300–0 fathoms and 800–0 fathoms as well as at the surface; at the remaining nineteen stations it

was taken in surface hauls only. At one station (4652) the species is recorded from 100–0 fathoms; at one station (4655) in hauls from 300–0 fathoms and 400–0 fathoms; and at three stations (4647, 4651, 4670) in hauls from 800–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The species is also recorded from surface waters in Panama Harbor, in the Panamic Area. This station is not included in the 127 stations mentioned above.

The temperature range of these fifty stations at the surface was 65°–85°; the average was 74.3°. At the twenty-eight stations in the surface catches of which this species was found, the surface temperature ranged from 67° to 84°; the average was 75.1°.

For the surface catches the following frequencies are recorded: — 72% at one station (4571), 29% at one station (4611), 11% at one station (4649), 10% at one station (4669), 9% at one station (4639), 6% at one station (4615), 5% at one station (4640), 3% at three stations (4657, 4659, 4676), 2% at three stations (4644, 4650, 4544), 1% at four stations (4574, 4588, 4666, 4716), and less than 1% at the remaining stations. For the catches from 100, 300, 400, or 800 fathoms to the surface the records of frequency are as follows: — 12% at one station (4659), 9% at one station (4571), 3% at one station (4650), 2% at nine stations (4574, 4598, 4609, 4638, 4651, 4655, 4671, 4675, 4676), 1% at nine stations (4613, 4617, 4637, 4647, 4657, 4663, 4667, 4670, 4715), and less than 1% at the remaining stations. In the catch from Panama Harbor thirty specimens were found.

This species was first recorded by Saville-Kent (1881) from the Adriatic Sea. From the North Sea it is reported by Cleve (1900e, 1903a), Apstein (1905a), Clark (1905), Ostenfeld (1906), and Paulsen (1912). It has never been found in the Baltic. Lemmermann's (1902a, p. 263) statement that Möbius (1887) recorded it from the western part of the Baltic is erroneous. Jörgensen (1905) found it near Bodö, on the west coast of Norway. It is mentioned as occurring in the Norwegian Sea by Cleve (1902a), Gran (1902), Ostenfeld (1906), Linko (1907), and Paulsen (1912). From the northern part of the Atlantic (*i.e.*, west of Scotland, south of the Faroe Islands and of Iceland, and in the Irminger Sea) it is reported by Hensen (1887, 1911), Möbius (1887), Ostenfeld (1898b, six stations; 1899, seven stations), and by Paulsen (1904, 1912). In the English Channel it was found by Cleve (1899a, 1900e) and Ostenfeld (1916b); on the west coast of France by Mangin (1912) and Jörgensen (1923); on the west coast of the Pyrenean peninsula by Jörgensen (1923); and west of Gibraltar by Gräf (1909). In the northern and middle parts of the Atlantic it has been recorded by the following investigators: — Cleve (1897a), at lat. 49° 53′ N., long. 28° 13′ W., and at

lat. 37° 47′ N., long. 47° 31′ W.; Cleve (1901c) at about fifty stations between lat. 63° N. and lat. 10° N.; Cleve (1902b), at four stations between lat. 39° N. and lat. 21° S.; Cleve (1903b) at lat. 36° N., long. 6° W., and at lat. 37° N., long. 8° W.; Ostenfeld (1898a) at lat. 35° 44′ N., long. 38° 03′ W., and at the Canary Islands; Murray and Whitting (1899) at forty stations between lat. 48° N. and lat. 20° N.; Zacharias (1906) near the Azores and at lat. 31° N., long. 38° W.; Karsten (1906) at six stations between lat. 33° N. and 1° N.; Lohmann (1908a) between lat. 39° N., long. 46° W., and lat. 35° N., long. 53° W.; Stüwe (1909) at lat. 28° N., long. 40° W.; and Hensen (1911) at a great number of stations in the Labrador Current, Gulf Stream, Florida Current, Sargasso Sea, Canary Current, North Equatorial Current, Guinea Current, South Equatorial Current, and off the northeastern coast of Brazil. In the Caribbean Sea and among the West Indies this species has been found by Grenfell (1887), Murray and Whitting (1899), who record it at fourteen stations, and by Cleve (1901c) and Schröder (1909). From the South Atlantic we have the following records: — Cleve (1900f), "not rarely, in almost all samples from 37° S., 23° W. to 44° S., 4° E."; Cleve (1901c) off Rio de Janeiro; Cleve (1902b) at lat. 38° S., long. 20° W. to 44° S., long. 4° E.; Karsten (1906) at eleven stations between lat. 5° S. and lat. 35° S.; and Faria and Cunha (1907), Cunha and Fonseca (1907), off Rio de Janeiro. General statements about the occurrence of this species in the Atlantic are to be found in Stein (1883), Cleve (1899c, 1900f, 1901c), and Cleve, Ekman, and Pettersson (1901).

In the Mediterranean this species has been observed on a great number of occasions, viz.: at lat. 36° N., long. 5° W., by Cleve (1903b); at lat. 36° 46′ N., long. 2° 25′ E., by Ostenfeld (1902); in the Gulf of Lyons by Pouchet (1883), Gourret (1883), and Pavillard (1905, 1909, 1916); off Monaco by Nathansohn (1908, 1909, 1910a); in the Ligurian Sea by Forti (1922); off Naples by Daday (1888), Schröder (1900a), and Zacharias (1906); off Palermo and Algiers by Zacharias (1906); in the Adriatic Sea by Saville-Kent (1881), Stein (1883), Imhof (1886), Entz (1902b, 1905), Schröder (1906a, 1911), Zacharias (1906), Schiller (1911a, 1911b, 1912), and Carazzi and Grandori (1912). Jörgensen (1923) found it to be comparatively well represented throughout the Mediterranean. From the Marmora Sea, Golden Horn, and Bosporus it has been recorded by Zacharias (1906), Lindemann (1923), and Jörgensen (1923). In the Black Sea it was found by Minkiewitsch (1899), Reinhard (1910), and Jörgensen (1923).

From the Red Sea the species has been reported by Ostenfeld and Schmidt (1901), Cleve (1903b), and Karsten (1907); from the Gulf of Aden, by Ostenfeld

and Schmidt (1901), Cleve (1903b), Schröder (1906a), and Karsten (1907); from "the coast of Arabia," by Jörgensen (1923, p. 29); from the Arabian Sea, by Ostenfeld and Schmidt (1901), Cleve (1903b), Schröder (1906a), Karsten (1907), and Czapek (1909); from the Indian Ocean, by Cleve (1900f, 1901a), Karsten (1907), and Gräf (1909). In the Antarctic Ocean, south of South Africa, it was found by Karsten (1905) at two stations, viz., at lat. 37° 31′ S., long. 17° 1′ E., and at lat. 41° 5′ S., long. 14° 51′ E.; and by Gräf (1909) at three stations, viz., lat. 39° 56′ S., long. 20° 7′ E., lat. 43° 39′ S., long. 23° 30′ E., and lat. 42° 21′ S., long. 31° 0′ E. Lemmermann (1899a) found it in the Peruvian Current.

Cleve (1901a) recorded this species from the Malay archipelago; van Oye (1921) from Batavia, Java; Gräf (1909) from the north coast of New Guinea; Schmidt (1901) from the Gulf of Siam; Ostenfeld (1915) from the coast of Celebes; Schröder (1906a) from the Formosa Strait; Okamura (1907, 1912) from Japanese waters; Stein (1883) from the "Südsee"; and Whitelegge (1891) from Sydney, on the east coast of Australia.

Karsten (1907) reported the species to have been taken with a closing net between 200 and 100 meters. Most of the remaining records refer to surface hauls.

Some investigators, *e.g.* Jörgensen (1923), have found this species to be "remarkably numerous" or even "abundant" at some localities.

According to the investigators who have contributed to our knowledge of the distribution of this species, it occurs in waters of the following temperatures and salinities. Ostenfeld (1898b): — temperature: range, 47.5°–53.6°; mean of six observations, 50.7°. Salinity: range, 35.25–35.50; mean of six observations, 35.39. Ostenfeld (1899): — temperature: range, 48.6°–53.4°; mean of seven observations, 50.6°. Salinity: range, 35.33–35.55; mean of seven observations, 35.43. Ostenfeld (1902): — temperature, 73.4°; salinity, 36.9. Murray and Whitting (1899): — temperature: range, 55°–86°; mean of 53 observations, 71.0°. Ostenfeld and Schmidt (1901): — temperatures, 80.1° and 79.1°. Cleve (1901a): — temperatures, 53.9° and 80.3°; salinities, 33.71 and 34.69. Cleve (1901c): — temperature: range, 42.8°–81.0°; mean of 100 observations, 65.3°. Salinity: range, 31.01–36.54; mean of 77 observations, 35.54. Cleve (1902a): — temperature, 48.2°; salinity, 35.42. Cleve (1902b): — temperature, 61.4° and salinity, 35.77 (means of 26 observations). Cleve (1903b): — temperature: range, 60.3°–84.7°; mean of seven observations, 73.2°. Salinity: range, 35.77–42.81; mean of seven observations, 37.95. Cleve, Ekman, and Pettersson (1901): — average temperature, 65.3°; average salinity, 35.54. Jörgensen (1905): — temperatures,

39.7° and 39.9°. Stüwe (1909): — temperature, 75.2°. Gräf (1909): — salinity: range, 34.09–36.33; mean of nine observations, 35.13. Van Oye (1921): — salinity, 31.5.

Of the authors mentioned in connection with the distribution of this species, only the following have given descriptions or figures, by means of which their determinations of this species may be checked: — Saville-Kent (1881), Pouchet (1883), Stein (1883), Gourret (1883), Entz (1902a), Czapek (1909), Reinhard (1910), Schröder (1911), Pavillard (1916), Forti (1922), Lindemann (1923), and Jörgensen (1923).

Dinophysis caudata is eupelagic and occurs in tropical, subtropical, and warm-temperate regions of all seas. It has been found in the northern part of the Atlantic, in the North Sea, and in the Norwegian Sea, but it is probably a warm-water species and not endogenetic in these relatively cool regions. The records of the International Council for the Investigation of the Sea "decidedly support the notion that the specimens found in these northern waters are of southern origin, carried to the north by the Gulf Stream" (Paulsen, 1912, p. 290). The species is eurythermal, with an exceptionally wide amplitude of thermal adaptation, viz., 39.7°–85.0°, and euryhaline, occurring in brackish water as well as in waters with a salinity as high as 42.81‰ (see Jörgensen, 1923, p. 27). It is probably one of the most common representatives of this family (see Cleve, 1901c, p. 240, and Jörgensen, 1923, p. 27). Its distribution in the Eastern Pacific, according to our data, is very peculiar, since almost all the record stations are located in the coastal currents. Its almost complete absence from the South Equatorial Drift is not directly due to the temperature, since this region is thermally intermediate between the relatively cool Peruvian Current and the very warm Mexican Current and Panamic Area, where the species is rather common. The comparatively frequent occurrence of this species in our surface catches (twenty-eight surface records) is another outstanding feature. Of *D. hastata*, which next to *D. caudata* is the most common species of this genus in our surface catches, we have only eight surface records. Furthermore, it should be remembered that some of our surface records of *D. caudata* showed exceptionally high frequencies.

Dinophysis caudata Saville-Kent f. acutiformis, nom. f. nov.

Figure 46

Dinophysis homunculus var. *ventricosa* Pavillard, 1916, p. 56, fig. 15B. Forti, 1922, p. 108, 190, 208, fig. 115.

Dinophysis caudata var. *ventricosa* Jörgensen, 1923, p. 25, 27–29, fig. 32, 37.

Diagnosis: — This form, which is rather variable in shape, differs from the main species chiefly in its smaller size and its less-developed peduncle. The body

measures 66.7–86.6 μ in length. The peduncle sometimes is fairly well developed, sometimes it is hardly distinguishable; when best developed, its length is about 0.25 the length of the body. The cingular and sulcal lists, as a rule, have less developed structural differentiation than in the main species.

Coastal waters in the Atlantic, Mediterranean, Arabian Sea, and the eastern tropical Pacific.

Dimensions: — Our specimens: Length of body, 71.5–86.6 μ (average, 81.4 μ). Greatest depth of body, 38.5–47.4 μ (average, 44.2 μ). The type specimen, as figured by Pavillard (1916, fig. 15B), was 82.5 μ long and 41.8 μ deep. The specimens figured by Jörgensen (1923, fig. 32, 37) were 66.7–74.0 μ long and 32.0–38.1 μ deep.

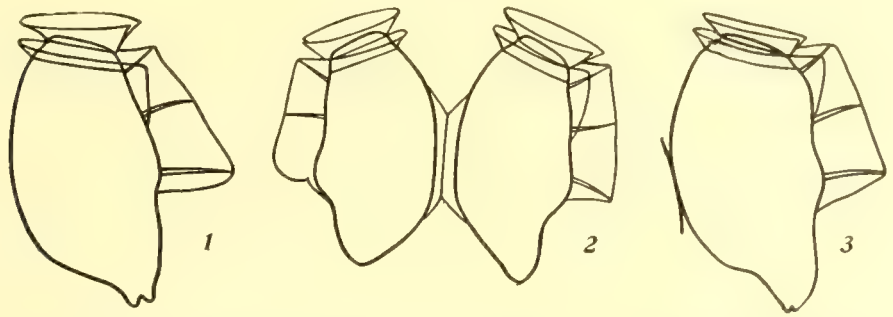

FIGURE 46.— *Dinophysis caudata* Saville-Kent f *acutiformis*, nom. f. nov., right lateral view. 2, two schizonts, not yet detached from each other; 3, two schizonts, one of which is indicated only by a portion of its dorsal margin. × 430. Station 4673 (300–0 fathoms).

Variations: — Judging by the seven specimens as yet figured, this form is rather variable in the size of the body, in the depth and shape of the anterior portion of the body, and in the size and shape of the peduncle. The anterior portion of the body may be rather deep and bulky (Jörgensen, 1923, fig. 32; our Figure 46: 3) or relatively slender (Figure 46: 2), and the peduncle may be well developed (Pavillard, 1916, fig. 15B; Jörgensen, 1923, fig. 32) or hardly distinguishable (the left specimen in Figure 46: 2).

Comparisons: — The specimens found in the material of the Expedition and in the present paper referred to *Dinophysis caudata* f. *acutiformis* agree rather closely with Pavillard's (1916, fig. 15B) figure of the type specimen of this form. They differ from the type and from the specimens figured by Jörgensen (1923, fig. 32, 37) mainly in having, to varying degrees, somewhat less-developed peduncles.

This form has an uncertain systematic status. It may be a distinct species; or it may be a subspecies of *Dinophysis caudata* as assumed in this paper. The evidence bearing on this question is anything but conclusive. Our tentative deci-

sion is based on the following facts: — (*1*) While the typical *D. caudata* is rather commonly found in waters far from the coast as well as in coastal waters, *D. caudata* f. *acutiformis* has never been recorded except from near the coast line, where the hydrographical conditions are more or less changeable and different from those of the open sea; (*2*) a series of specimens of *D. caudata* has been found, which is characterized by a gradual decrease in the size of the peduncle. As far as available records go, such specimens, too, have not been taken except near the coast; (*3*) Jörgensen (1923, fig. 37) has figured a specimen in which one valve has a fairly well-developed peduncle and the other valve only a slight indication of a peduncle. For further discussion of the systematic significance of this specimen, see *D. caudata*, the section on variations.

The systematic status of the following two species must also be regarded as uncertain: — *Dinophysis diegensis* Kofoid and its varieties *curvata* Kofoid and *caudata* Pavillard (the name of the last variety is preoccupied and therefore must be changed), and *D. subdiegensis* Jörgensen. These two species have been supposed to be nothing but modifications of *D. caudata*, but they may be independent species. Just as in the case of *D. caudata* f. *acutiformis*, the evidence bearing on the question is of uncertain value. It should be mentioned that, just as *D. caudata* f. *acutiformis*, these two species are not known to have been taken except near the coast line.

Dinophysis diegensis Kofoid is considered a distinct species by Kofoid (1907b, p. 313, pl. 33, fig. 57, 59, 60), Ostenfeld (1915, p. 7), Pavillard (1916, p. 57), and, with hesitation, by Jörgensen (1923, p. 28, fig. 36). It is held as a degenerate form of *D. caudata* by Jörgensen (1923, p. 22, 25, 27; see also Forti, 1922, p. 109). *D. diegensis* var. *curvata* Kofoid (1907b, p. 313, pl. 33, fig. 58, 61) and *D. diegensis* var. *caudata* Pavillard (1916, p. 57, pl. 3, fig. 2; 1923a, p. 881) are considered as degenerate forms of *D. caudata* by Jörgensen (1923, p. 27, 28).

Jörgensen (1923, p. 27, 28, 43, 44, fig. 35) is, at present, the only one who has treated *Dinophysis caudata* var. *subdiegensis*. He first established this form as a distinct species under the name of *D. kofoidi;* then, on page 28 of the mentioned paper, he changed his opinion and treated it as a degenerate form of *D. caudata* under the name of *D. caudata* var. *subdiegensis* (the last name has the priority).

Whatever the systematic status of *Dinophysis caudata* f. *acutiformis*, *D. diegensis*, and *D. subdiegensis* may be, there seems to be but little doubt that they are very closely related to *D. caudata*. Indeed, these forms most probably have overlapping ranges of variation. *D. caudata* f. *acutiformis* is in several respects

intermediate between the typical *D. caudata* on the one hand and *D. diegensis* and *D. subdiegensis* on the other.

Synonymy: — This form was established by Pavillard (1916), who described and figured it under the name of *Dinophysis homunculus* var. *ventricosa*. Later Jörgensen (1923, fig. 32) figured it under the name of *D. caudata* var. *ventricosa* and (1923, fig. 37) as "a degenerate form" of *D. caudata*. Forti (1922, fig. 115) reproduced Pavillard's (1916) figure of the type specimen.

Unfortunately, the name *ventricosa*, suggested by Pavillard (1916), must be rejected on account of preoccupation by *Dinophysis ventricosa* Claparède and Lachmann (1858, p. 408).

Occurrence: — *Dinophysis caudata* f. *acutiformis* is recorded at only one (4673) of the 127 stations, on the second line of the Expedition, in the Peruvian Current, and very near the coast. The depth is 300–0 fathoms, the surface temperature 67°, and the frequency less than 1% (three specimens).

This form was first recorded by Pavillard (1916) from the Étang de Thau, an enclosed and very shallow part of the Gulf of Lyons. Later it was found by Forti (1922) in the Ligurian Sea, and by Jörgensen (1923) in the harbor of Lisbon, "in the innermost, less saline region" of the Mediterranean, and on the coast of Arabia, near Ras Dschibsch. There are no records of this form from waters far from the coast line.

Histiophysis, gen. nov.

Dinophysis Kofoid & Michener, 1911, p. 293 *partim*.

Diagnosis: — Body ovate in lateral outline. Epitheca low, about 0.26 as deep as hypotheca. Dorsally transverse furrow is about 0.19 the greatest depth of body and about twice as wide as ventrally. Posterior cingular list about 0.11 the length of body from apex. Anterior cingular list funnel-shaped, ribbed; its dorsal height about 0.30 the greatest depth of body. Posterior somewhat narrower and more inclined than anterior, reticulate but not ribbed. Right sulcal list long, narrow, and reticulated. Left sulcal list ends somewhat ventrally to antapex and increases gradually in width posteriorly, where it is angular and about 0.46 the greatest depth of body; the entire list reticulated; with no main rib behind fission rib.

The type species is *Histiophysis rugosa*.

Histiophysis rugosa (Kofoid and Michener)

Plate 5, fig. 5. Figure 93: 1

Dinophysis rugosa Kofoid & Michener, 1911, p. 293.

Diagnosis: — Body broadly ovate in lateral view; length: depth, 1.08: 1. Posterior cingular list about 0.11 the length of body from apex. Cingular lists funnel-shaped; anterior ribbed, 0.30 the depth of body; posterior finely reticulate, somewhat narrower. Left sulcal list ends somewhat ventrally to antapex; increases gradually in width posteriorly; dorsal margin gently sigmoid, 0.46 the depth of body, forming acute angle of 60° with ventral margin; with only one rib, the fission rib, which is 0.20 the depth of body; entire list reticulate; meshes decreasing in size posteriorly, where they are very small. Theca finely and deeply areolate. Length, 45.7 μ.

Eastern tropical Pacific.

Description: — This is a medium-sized species, the body of which is broadly ovate in lateral view, broadly rounded posteriorly and rather narrowly rounded anteriorly. It is deepest just behind the middle, and the ratio between the length and the depth is about 1.08: 1. The longitudinal axis is subperpendicular, slightly deflected posterodorsally.

The epitheca is about 0.26 as deep as the hypotheca; its shape is unknown but is probably gently convex. Dorsally the transverse furrow is about 0.19 the greatest depth of the body and about twice as wide as ventrally; its shape is unknown. The posterior cingular list is about 0.11 the length of the body from the apex. The hypotheca is subcircular, somewhat narrower anteriorly than posteriorly, and its margins are confluent.

The anterior cingular list is sessile, with a well-developed funnel shape and an anterior inclination of about 35°; it flares about twice as much dorsally as ventrally, with the dorsal side more concave than the ventral; with flat, slightly inclined top; its height is about 0.30 the greatest depth of the body, and it has on each valve about 11–13 ribs; most of these are complete and simple, others are incomplete or anastomose proximally. The posterior cingular list is somewhat narrower and more inclined than the anterior; it lacks ribs but is finely and rather heavily reticulated throughout. The right sulcal list is long, narrow, and finely and rather heavily reticulated throughout; it extends to the fission rib of the left sulcal list, *i.e.*, to a point about two thirds the way from the apex to the antapex; it is of subuniform width throughout, and its width about equals 0.06 the greatest depth of the body. The left sulcal list ends somewhat ventrally to the antapex

and increases gradually in width posteriorly. Its ventral margin is strongly and somewhat irregularly convex except anteriorly and posteriorly, where it is gently concave. Its dorsal margin (postmargin) has a posteroventral inclination of about 25°, is gently sigmoid, concave anteriorly and convex posteriorly, forms an acute angle of about 60° with the ventral margin, and its length is about 0.46 the greatest depth of the body. The list has only one rib, the fission rib, located at a point about two thirds the way from the apex to the antapex, deflected posteriorly at about 20°, and measuring 0.20 the greatest depth of the body. In front of this rib the list is irregularly and rather coarsely reticulated, most of the meshes being elongated transversely, and the margin is finely undulating. Behind this rib the list is finely and rather heavily reticulated, the meshes decreasing in size posteriorly, and the margin is not undulating but smooth.

The thecal wall is finely, deeply and regularly areolate. Across the middle of each valve there are about twenty-two areoles. Some phaeosomes were found in the girdle of the type specimen.

The dimensions of one specimen only, the type, were measured.

Dimensions: — Length of body, 45.7 μ. Greatest depth of body, 42.8 μ.

Comparisons: — Our description and figure are based on the type specimen.

Synonymy: — This species was established by Kofoid and Michener (1911) under the name of *Dinophysis rugosa*.

Occurrence: — *Histiophysis rugosa* is recorded from only one (4705) of the 127 stations, on the fourth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, and at a surface temperature of 72°. The frequency is less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4705 of the Expedition, which thus is the type locality.

2. AMPHISOLENIDAE, fam. nov.

Diagnosis: — Body divided, for purpose of description, into five regions: — head, neck, anterior process, midbody, and antapical (or antapicals). Sometimes strikingly elongated, straight, or somewhat sigmoid; with two long and narrow extensions arising from midbody, one anterior, made up of head, neck, and anterior process, the other posterior, forming the antapical; and with longitudinal axis of body passing through regions from which anterior process and antapical originate. Sometimes seemingly tripartite, with three long and narrow extensions arising from midbody, one anterior, made up of head, neck, and anterior process,

and two posterior, the antapicals, one dorsal, the other ventral in origin; the three extensions generally subequal, approximately balanced, and their length 1.0–3.4 the dorsoventral diameter of midbody measured between bases of antapicals.

Head encircled by girdle; its axial length 0.11–1.00 the length of neck; its dorsoventral diameter (width) 0.5–10.0 its axial length. Epitheca very small; its axial length less than half that of head; its anterior face convex to concave. Neck elongated, cylindrical or slightly flattened bilaterally, 0.02–0.28 the length of body and 2.5–22.0 times longer than wide. Anterior process somewhat wider than neck; when set off from midbody, it is about as long as, or generally somewhat shorter than, neck. Midbody more or less compressed bilaterally, in lateral view of varying shapes, fusiform, ovoidal, subtriangular, subrotund, subellipsoidal or sack-shaped. Antapical (or antapicals) of varying lengths, 0.9–33.0 the length of neck, and about as wide as or slightly wider than neck.

Distal portion of girdle not displaced posteriorly. Transverse furrow flat or somewhat convex or concave, of subuniform width throughout and somewhat narrower than and slightly oblique to head. Longitudinal furrow at most but slightly impressed, extending from girdle to base of neck; it does not extend beyond the girdle, *i.e.*, into the epitheca. Cingular lists subequal or nearly so, of moderate height, 0.5–3.0 the width of transverse furrow, hyaline, and generally ribbed, the anterior one with midventral gap. Sulcal lists also of moderate height, extending to or somewhat beyond flagellar pore, simple, less differentiated than in other families, hyaline, and frequently without ribs; fission rib, when present, near flagellar pore. Flagellar pore displaced to posterior end of neck. Transverse flagellum extending from flagellar pore into girdle and around head. Longitudinal flagellum not observed with certainty.

Thecal wall in most cases apparently without structure, seldom striate, pitted or locally reticulate. Nucleus located in midbody. Pusule developed, opening into flagellar pore. Chromatophores, if present, pale yellowish green, brownish, or colorless.

Length of body ranging from 92 μ to 1520 μ.

Marine and eupelagic, probably of wide distribution in tropical, subtropical, and warm-temperate waters.

Subdivisions. Relationships between the Genera

In the present paper all the known species of the family Amphisolenidae have been assigned to either of two genera, Amphisolenia and Triposolenia. These two genera, which probably represent natural systematic units, are sharply set off

from each other. Although, at the first glance, they appear to present two rather different types, there seem to be good reasons in favor of the supposition that they are closely related. Their close relationship is indicated by the following structural characteristics. (*1*) The anterior portion of the body, which for the purpose of description is divided into three regions, head, neck and anterior process, is prolonged and attenuated. (*2*) The head as a rule is short and is surrounded by the girdle. The epitheca is therefore very short. (*3*) The neck is comparatively long and narrow. (*4*) The flagellar pore is displaced to the posterior end of the neck. (*5*) The transverse furrow is somewhat narrower than and slightly oblique to the head. The longitudinal furrow extends from the girdle to the posterior end of the neck and does not extend into the epitheca. (*6*) The cingular lists are subequal or nearly so, of moderate height, 0.5–3.0 the width of the transverse furrow, hyaline, and generally ribbed. The sulcal lists are also of moderate height, simple, less differentiated than in the other families of this tribe, hyaline, frequently without ribs, and extend to or somewhat beyond the flagellar pore. The fission rib, when present, is near the flagellar pore. (*7*) Around the flagellar pore a cytopharyngeal protuberance generally is developed. (*8*) The portion of the body which is just behind the anterior process is inflated and contains the nucleus. (*9*) The posterior portion of the body is prolonged and attenuated. (*10*) In Triposolenia the middle portion of the body is always bifurcated. In the most highly differentiated species of Amphisolenia, viz., those belonging to the Bifurcata group, the posterior portion of the body has one or more branches. This constellation of characters differentiates these two genera from all other known genera of Dinophysoidae.

The distinctive characters of Triposolenia, when compared with those of Amphisolenia, are: — (*1*) the shape of the strongly bilaterally compressed midbody, (*2*) the presence of two antapical processes arising from the midbody, one dorsal, the other ventral in position, both in most species being almost similar in size and the one the mirror image of the other, and (*3*) the fact that the longitudinal axis of the body does not pass through the region of the midbody from which arises the antapical process that corresponds to the original posterior portion of the body. The relation which the midbody in Triposolenia bears to its three approximately balanced processes, viz., the anterior process with the neck and the head, and the two antapicals, strikingly distinguishes this genus from all the other known genera of Dinophysoidae. In Amphisolenia, (*1*) the midbody in most cases is decidedly less compressed bilaterally than in Triposolenia, (*2*) only one antapical process arises from the midbody, and (*3*) the longitudinal axis of

the body passes through the region of the midbody from which the antapical originates.

With regard to the shape of the midbody transitional types between these two genera do exist, *e.g.*, *Amphisolenia inflata;* but with regard to the number and position of antapical processes no transitional types have been found as yet, but accessory antapical processes in Amphisolenia arise solely from the antapical and not from the midbody.

There seems to be but little doubt that, among the species of Amphisolenia hitherto described, *A. inflata* is the one that is most closely related to Triposolenia. It can be regarded as equally certain that, among the known species of Triposolenia, *T. truncata* is the one most closely related to Amphisolenia. These two species show important similarities in the following respects: — (*1*) the concavity of the anterior face of the epitheca, a character not found in any other species of these two genera; (*2*) the very distinct structural differentiation of the thecal wall which is almost identical in the two species in spite of its relative complexity and is unique as far as these two genera are concerned; (*3*) the well set off anterior process, and the relatively large, bilaterally compressed midbody; (*4*) the absence of antapical tubercles; (*5*) small size of the body. The coexistence of all these characters is most probably not the result of convergence but of common inheritance. If this statement is correct, then *Amphisolenia inflata* represents a type rather similar to the ancestral type of the genus Triposolenia; and *Triposolenia truncata* is the most primitive of all the known members of its genus. On the other hand, it does not follow that *Amphisolenia inflata* is necessarily the most primitive species of its genus. It is, of course, possible that Triposolenia originated from Amphisolenia after the latter had passed through a period of differentiation. The position of *Amphisolenia inflata* in the natural system must be judged in the light of facts gathered from a comparative morphological study of Dinophysoidae. Such a study shows that this species occupies a rather isolated position in Amphisolenia, and that it probably is one of the most primitive, possibly the most primitive, of the known species of this genus. The following of its characters appear to be more or less primitive: — (*1*) the small size of the body; (*2*) the straight longitudinal axis of the body; (*3*) the exceptionally large, bilaterally compressed midbody; (*4*) the simple, unbranched antapical; (*5*) the well-developed areolation and reticulation of the thecal wall; (*6*) the reticulation of the sulcal lists; (*7*) the continuation of the sulcal lists beyond the flagellar pore to the posterior end of the anterior process. The question as to whether or not the concavity of the anterior face of the epitheca of this species is primitive cannot be

settled as yet. It is a peculiarity of this species and of *Triposolenia truncata* which has not been found in any of the primitive genera of Dinophysoidae. We also leave the question open as to whether or not the peculiarity of having the anterior process well set off from the midbody is a primitive feature.

The result of this analysis is therefore: — (*1*) that the genera Amphisolenia and Triposolenia are more closely related to each other than to any other genus of this tribe; (*2*) that Triposolenia probably originated from an ancestral form of about the same habitus as *Amphisolenia inflata;* and (*3*) that of the known species of these two genera *Amphisolenia inflata* and *Triposolenia truncata* probably are the most primitive.

Did Triposolenia originate from Amphisolenia by a sudden duplication of the antapical, or by a gradual development of the accessory antapical, in other words, in the same way as *Dinophysis miles* Cleve probably arose from the *Dinophysis caudata* type? This problem cannot be settled as yet. The first alternative appears to be supported by the fact that the antapicals are better balanced in *Triposolenia truncata* than in most of the remaining species of this genus. Furthermore, sudden duplication of parts is a phenomenon frequently met with in Nature. The second alternative is not supported by the shape and the relative size of the antapicals in any of the known species of Triposolenia. On the other hand, the geniculation at the junction of the anterior process and the neck may possibly indicate that the anterior portion of the body, in order to maintain a state of equilibrium, may have been tilted first ventrally and then dorsally during a gradual growth of the accessory antapical. The ventral antapical, which in this case would correspond to the original posterior portion of the body, for the same reason may have shifted ventrally at the same time.

Distribution

The two genera of the family Amphisolenidae probably are exclusively marine and eupelagic and seem to be confined to waters of tropical, subtropical, and warm-temperate nature or origin. Both of them probably have a world-wide distribution in these waters, but as yet the genus Triposolenia has been recorded only from the eastern portion of the Pacific, from the southwest coast of Portugal, from the Mediterranean and from the Marmora Sea.

Most of the species appear to be rare. Some of the species of Amphisolenia have been recorded rather frequently from surface waters, but the optimum habitat of both genera appears to be in the deeper levels of photosynthesis, predominantly above 200 meters.

Key to the Genera

1. Midbody with one antapical which is sometimes divided distally.....Amphisolenia Stein, 1883.
2. Midbody with two antapicals.....Triposolenia Kofoid, 1907.

Amphisolenia Stein

Amphisolenia Stein, 1883, p. 24. Bütschli, 1889, p. 945, 1010. Schütt, 1896, p. 28. Delage & Hérouard, 1896, p. 385.

Diagnosis: — Body strikingly elongated, straight or somewhat sigmoid, often asymmetrical posteriorly. With two long and narrow extensions arising from midbody, one anterior, made up of head, neck, and anterior process, the other posterior, forming the antapical. Longitudinal axis of body passing through regions from which anterior and posterior extensions originate. In some species the posterior part of the antapical has one to four ventral branches.

The type species is *Amphisolenia globifera.*

Organology:—While for the sake of simplicity in quantitative determinations of structural features, in Triposolenia a more or less arbitrary longitudinal axis of the body has to be chosen, in Amphisolenia the original and, for most genera of Dinophysoidae, the typical axis can be utilized. In the species of Amphisolenia with an unbranched antapical, the longitudinal axis of the body either is straight or nearly so, or it has a slight or moderate sigmoid curvature, with the neck somewhat deflected dorsally and the antapical more or less concave ventrally. In some of these species the posterior portion of the antapical is bent ventrally, as in *A. astragalus* (see this species, the section on comparisons), or to the right, as in *A. clavipes* and *A. lemmermanni*, at an angle of about 25°–50°. In the species with a branched antapical, *e.g.*, in *A. quinquecauda*, the antapical often is characterized by a more or less strikingly developed sigmoid curvature in the dorsoventral plane; in other words, the longitudinal axis of the body may have a double sigmoid curvature. Sometimes the diversifications in the longitudinal axis of the body are accompanied by sinistral torsion.

The body is strikingly elongated, with two long and narrow extensions arising from midbody, one anterior made up of head, neck, and anterior process, the other posterior, forming the antapical. Just as in Triposolenia, the body in Amphisolenia frequently is characterized by a combination of asymmetry, both bilateral and dorsoventral, with a condition of balance.

The *head* (*hd.*, Figure 47) is composed of the very short epitheca, the girdle region, and a short, generally expanded region at the anterior end of the neck. It is encircled by the transverse furrow, which covers about two thirds or even more of its axial length. Its form and size vary rather strikingly in the different species. It is bilaterally compressed, and its transdiameter is not much greater

than that of the neck. In most species it is small, its axial length being between 0.11 and 0.30 the length of the neck and its dorsoventral diameter (its "width," according to the terminology utilized in this paper) between 1.0 and 4.0 its axial length. In *Amphisolenia inflata* it is 0.38–0.50 the length of the neck and about twice as wide as long. In *A. laticincta* it is about 1.0 the length of the neck and 0.5 as wide as long. In *A. asymmetrica* it is 0.13–0.14 the length of the neck and not less than 9–10 times wider than long. In lateral view, the anterior face of the head, *i.e.*, the epitheca, is more or less convex in most species; sometimes it is flat and in one species, *A. inflata*, even quite concave. In a few species the head is subhorizontal, but generally it is more or less inclined, about 5°–45°, anteriorly, that is, its dorsal end is elevated.

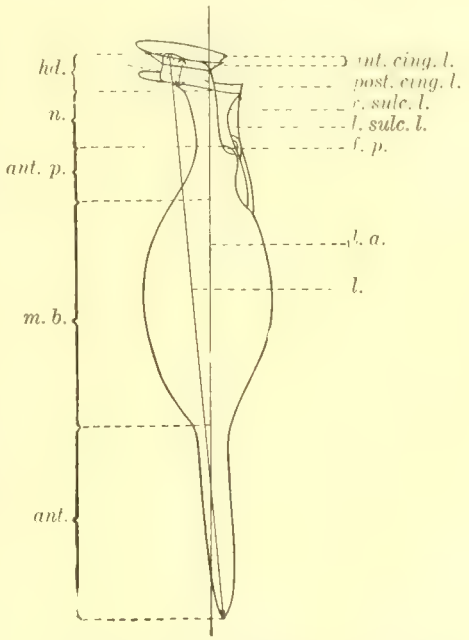

FIGURE 47.— *Amphisolenia inflata* Murray and Whitting, right lateral view. × 525. Station 4681 (300–0 fathoms). The length of body is measured in a straight line from foremost point of head to tip of antapical (in species with branched antapical, to tip of main stem of antapical). Our method of measuring the (axial) length of head is indicated by bicapitate barbed line crossing the head. The length of neck is the distance in a straight line from posteroventral point of head to flagellar pore. The length of anterior process is the distance in a straight line from midpoint of flagellar pore to midpoint of base of process. The lengths of midbody and antapical are measured in straight lines. (The lengths of antapical branches, on the other hand, are measured along curvatures from midpoints of bases of branches to tips.) Our method of measuring the anterior inclination of head is indicated by two dotted lines and a dotted arc; one of the lines is perpendicular to the longitudinal axis of body, the other runs parallel to dorsoventral midline of head.

Abbreviations:—*ant.*, antapical; *ant. cing. l.*, anterior cingular list; *ant. p.*, anterior process; *f.p.*, flagellar pore; *hd.*, head; *l.*, length of body; *l.a.*, longitudinal axis of body; *l. sulc. l.*, left sulcal list; *m.b.*, midbody; *n.*, neck; *post. cing. l.*, posterior cingular list; *r. sulc. l.*, right sulcal list.

The *neck* (*n.*, Figure 47) is an elongated, slender, and almost cylindrical extension of the anterior process. Its length, measured in a straight line from the posteroventral point of the head to the flagellar pore is 0.02–0.26 the length of the body. It is 2.5–22.0 times longer than wide, of nearly uniform caliber throughout, almost straight or gently curved dorsally, and generally slightly, 1°–20°, deflected dorsally from the longitudinal axis of the body. In most species the neck passes more or less abruptly into the head; in *Amphisolenia laticincta*, which has a head but slightly wider than the neck, the transition is gradual.

The *anterior process* (*ant. p.*, Figure 47), or the proabdomen according to Stein's (1883) terminology, is an anterior extension of the midbody. Contrary to the

anterior process in Triposolenia, it is usually very slightly, 1°–8°, deflected ventrally from the longitudinal axis of the midbody, which passes through the middle of its posterior end. Its length, measured in a straight line from the midpoint of the flagellar pore to the midpoint of the posterior end of the process (Figure 47), generally is very hard or even impossible to establish with accuracy. This is due to the fact that the process in most species merges gradually or even imperceptibly into the midbody. In a few species only, *e.g.*, in *Amphisolenia inflata*, the anterior process is rather well set off from the midbody. Sometimes, *e.g.*, in *A. inflata*, it is short and wide, 0.08–0.10 the length of the body and about as wide as long; sometimes, *e.g.*, in *A. schauinslandi*, it is long and narrow, approximately 0.16 the length of the body and about seven times longer than wide. Only exceptionally, as in *A. schauinslandi*, it is longer than the neck. It is almost cylindrical or slightly compressed bilaterally. In lateral view, it generally is 1.5–3.0 times wider than the neck. In some species it forms around the flagellar pore a more or less distinct *cytopharyngeal protuberance*. Just behind the flagellar pore there is in most species a longitudinal depression, which may be called the *cytopharyngeal depression* (Plate **13**, fig. 1). As far as our experience goes, the shape and the size of this depression cannot be utilized as specific characters, and nothing is known as to the significance of this structure.

The *midbody* (*m.b.*, Figure 47), or abdomen according to Stein's (1883) terminology, sometimes, *e.g.*, in *Amphisolenia inflata*, is well set off from both the anterior process and the antapical; sometimes, *e.g.*, in *A. laticincta*, it is well set off from the antapical but merges imperceptibly into the anterior process; in most species it merges more or less gradually into both the anterior process and the antapical; in a few species, *A. bispinosa* and *A. palaeotheroides*, it passes even imperceptibly into both the anterior process and the antapical. In *A. inflata* it is strongly compressed bilaterally, in the other known species the bilateral compression is rather slight. Seen from the side, its width and its shape are rather variable, not only in the different species but also within the species; for a possible explanation of the variability of the width of the midbody within the species, see the section on "Adaptive and systematic value of the characters" (p. 63). In *A. inflata*, the midbody of which is relatively very wide, the ratio between the length and the greatest width of the body is 4.2–4.3: 1; in *A. bidentata*, which is characterized by a very narrow midbody, the corresponding ratio is 46.3 (30.3–67.7): 1. The relative length of the midbody is very variable. In *A. brevicauda* the total length of the anterior process and the midbody about equals 0.50 the length of the body; in *A. extensa*, which is an extreme in the opposite direction,

the corresponding value is about 0.12. In *A. inflata* the midbody is ovoidal in lateral view; in *A. brevicauda* its dorsal margin is almost straight or even slightly concave, its ventral margin moderately convex; in all the other known species it is fusiform, generally narrowly fusiform.

The *antapical* (*ant.*, Figure 47), or postabdomen according to Stein's (1883) terminology, is a narrow, posterior extension of the midbody, a prolongation of the thecal wall with protoplasmic core. The longitudinal axis of the body passes through the middle of its anterior end. As mentioned in the last paragraph, the antapical sometimes is well set off from the midbody, sometimes it merges more or less gradually, even imperceptibly, into the latter. Its relative length is exceedingly variable. In *Amphisolenia brevicauda* it is only about 0.9 the length of the neck and 0.4 the total length of the anterior process and the midbody; in *A. extensa* it is 22–33 times longer than the neck and 4–7 times longer than the total length of the anterior process and the midbody. It is about as wide as or somewhat wider than the neck, of almost circular cross-section or but slightly flattened bilaterally, and in most species of uniform width throughout the greater part of its length; sometimes it tapers gently posteriorly, or its posterior part is more or less inflated, *e.g.*, in *A. thrinax* (Plate **12**, fig. 6). In most of the species the antapical is unbranched, in some of them it is branched.

Species with unbranched antapical: — In the most primitive of the species with unbranched antapical, *e.g.*, in *Amphisolenia inflata*, the antapical is straight, and its two valves are symmetrical. In some species, *e.g.*, in *A. curvata*, the antapical is characterized by a slight or moderate ventral concavity; in others its posterior part is bent ventrally, as in *A. astragalus*, or to the right, as in *A. clavipes* and *A. lemmermanni*, at an angle of about 25°–50°. The posterior portion of the antapical exhibits a rather striking variety of types and is very important in the characterization of the species. In *A. brevicauda*, for instance, this portion of the antapical tapers to a simple, acute point, without spinules or other structural differentiations. In *A. laticincta* it is rounded, not inflated, and has one minute spinule on the antapex (in fully developed specimens probably one spinule on each valve). In the species of the Extensa group it is slightly club-shaped, subtruncate, without spinules or with four or fewer exceedingly minute spinules on the antapex. In *A. schauinslandi* and in *A. rectangulata* it is truncate, rectangular, sometimes slightly inflated, and furnished with four short, acute spinules on the antapex, one on each of the four corners and two on each valve. In *A. inflata* and in the species of the Bispinosa group it is not or but slightly inflated, truncate in dorsoventral view, and has two lateral spinules on

the antapex, one on each valve. In the GLOBIFERA group it forms a knob-like expansion, in front of which there is a short, neck-like constriction; the antapex sometimes has four, sometimes two, and sometimes no spinules. In *A. schröderi* and *A. clavipes* it is more or less inflated and bent to the right, and has, on the antapex, two sagittal spinules, both probably belonging to the left valve. In the PALMATA group the posterior part of the antapical is bent to the right, somewhat inflated, truncate, and furnished with the following spinules: — at the point of bending the left valve has a rather strong, pointed, heel-like spinule; sometimes, *e.g.*, in *A. bidentata*, the antapex has two short, pointed, and fairly strong spinules on the left valve, one on each corner, but no spinule on the right valve; in other species, *e.g.*, in *A. palmata*, it has, besides these spinules of the left valve, one spinule on the right valve placed between the two spinules on the left valve.

SPECIES WITH BRANCHED ANTAPICAL: — In the species with branched antapical, the antapical stem often is characterized by a more or less strikingly developed sigmoid curvature in the dorsoventral plane (Plate **12**, fig. 6). Species with one, two, three, and four branches have been found. The branches originate along the sagittal suture and in binary fission therefore are split in half. As far as we have been able to establish, they are always ventral in origin. Sometimes the branches are almost straight, but generally they are curved or gently sigmoid. When the antapical is bifurcate, the posterior end of the main antapical stem and of the branch have about the same shape and structure as the posterior end of the antapical in *Amphisolenia palmata*. (With regard to *A. projecta*, see this species.) When two, three, or four branches are developed, the posterior end of the main antapical stem and of the proximal branch have about the same shape and structure as the posterior end of the antapical in *A. palmata;* the remaining one to three branches have no heel-spinule but only two or three distal spinules (Plate **13**, fig. 9–13).

The *transverse furrow* (Plate **13**, fig. 1, 6, 8, 14) forms an equatorial band around the short head and covers about two thirds or even somewhat more of its axial length. Its distal portion is not displaced posteriorly, *i.e.*, the furrow does not form a spiral about the head. Sometimes it is almost perpendicular to the longitudinal axis of the body, but in most species it is inclined anteriorly, due to the anterior inclination of the head; however, its inclination, as a rule, is somewhat less than that of the head. Its floor is flat or somewhat concave or convex; this character seems to be variable even within the species.

The *longitudinal furrow* (Plate **13**, fig. 1, 14) is long and extends in about a straight line from the transverse furrow to or a little beyond the posterior end of

the neck. Anteriorly it does not extend beyond the girdle, *i.e.*, into the epitheca. It is at most but slightly impressed.

The *lists of the furrows* are not excessively developed. They arise from low and narrow basal ridges (Plate **13**, fig. 1, 8), and are hyaline and exceedingly delicate. Frequently (Plate **13**, fig. 6) the basal ridges of the two cingular lists are connected by a varying number of simple, low, narrow, and often almost equidistant cross-ridges. In most species these cross-ridges are very regular, but sometimes they are more or less irregular (Plate **13**, fig. 8).

The *anterior cingular list* (*ant. cing. l.*, Figure 47) is a flaring sheet, open ventrally, of moderate and almost uniform width throughout the greater part of its length, and as wide as or about two to three times wider than the transverse furrow. It has a number of cross-ribs, which in most cases are simple and nearly equidistant, but sometimes, as in *Amphisolenia inflata*, are branched and not equidistant. The number of cross-ribs is very variable; from two to more than twenty-five on each valve have been observed. Sometimes the list is subhorizontal, but on the dorsal side of the head it generally flares anteriorly at an angle of about 10° to 40° from the transverse plane of the girdle.

The *posterior cingular list* (*post. cing. l.*, Figure 47) either has about the same width, inclination, and structure as the anterior, or else it is somewhat narrower and less inclined anteriorly, and its ribs are less developed, sometimes even absent.

The *sulcal lists* (*r. sulc. l.*, and *l. sulc. l.*, Figure 47), which form a direct continuation of the posterior cingular list, run about parallel to each other along the whole length of the neck. Posteriorly they diverge a little to enclose the flagellar pore, which is on the right valve. The left list either ends at the side of the flagellar pore, or it crosses the sagittal suture near the pore and continues for a rather short distance along the ventral side of the right valve of the anterior process. The right list generally ends at the side of the flagellar pore, but sometimes, as in *Amphisolenia inflata*, it continues along the ventral side of the anterior process. Both lists are of moderate width and generally are somewhat narrower than the cingular lists; the right list, as a rule, is slightly narrower than the left. Their width and shape are variable, even within the species. In most cases these lists decrease in width posteriorly, but sometimes they are characterized by a moderate increase in width near the flagellar pore. In some species, *e.g.*, in *A. laticincta* and *A. curvata*, there is what we have termed an *accessory sulcal list* arising from the originally free edge of the left sulcal list. The significance and morphological value of this structure are not known. However, it probably is a part of the left sulcal list that is resorbed in binary fission and regenerated after the development

of the other parts of the daughter individuals. With regard to the structural differentiation of the sulcal lists, the genus exhibits very little variety. In most cases the lists apparently are without structure, but sometimes the left list has a rib at the place where it crosses the sagittal suture. This rib is undoubtedly homologous with the *fission rib* of the left sulcal list in other genera of Dinophysoidae (Plate 13, fig. 6; see the section on the reproduction of the genus). Sometimes, as in *A. inflata*, the anterior parts of the lists are reticulated, or, *e.g.*, in *A. extensa*, they are furnished with irregular ribs. In *A. inflata* the left list has a characteristic thickened area near the flagellar pore and in front of this a cross-rib.

The *flagellar pore* (*f.p.*, Figure 47), or the mouth according to Stein's (1883) terminology, is a fairly large opening at the posterior end of the neck, or to express it in another way, at the anteroventral end of the anterior process. It leads into a narrow funnel, named the *flagellar fundus* by Willey and Hickson (1909, p. 187). It is located on the right valve (Plate 13, fig. 1), is ventrally surrounded by the cytopharyngeal protuberance, and its left lip is somewhat higher than the right; it therefore is directed anteriorly and somewhat to the right.

Nothing is known with certainty as to the characteristics of the *flagella*. However, in these structures Amphisolenia probably agrees with Triposolenia. In other words, the *transverse flagellum* probably arises in the flagellar pore, passes anteriorly between the sulcal lists, and encircles the head from the left around to the right as in all known girdled dinoflagellates. The *longitudinal flagellum* probably is rather short. The flagellum found in *Amphisolenia schauinslandi* (Plate 7, fig. 3) corresponds to the longitudinal flagellum in that it does not have the close-set sinuosities, which so often characterize the transverse flagellum when fixed in formalin.

The *thecal wall* is rather thin and of nearly uniform thickness, except in spinules and other structural differentiations of the antapical. In most species it is hyaline and, under comparatively low magnifications, apparently without structure. However, when these species are examined under high magnifications, the thecal wall proves to be faintly and minutely spotted or flecked. In *Amphisolenia inflata* it is characterized by plainly visible pits and reticulations; this undoubtedly is the more primitive condition. In a great number of species minute pores, frequently arranged in longitudinal rows, are found on the neck and on the posterior portion of the antapical. Sometimes minute pores also are found on the head, anterior process, and midbody. In the species with two or more branches on the antapical, the posterior part of the original antapical stem and of the proximal

antapical branch is porulate, but the remaining antapical branch or branches lack pores.

The *sagittal suture* of the two valves is marked by a rather faint line and by pores (see the section on the reproduction of this genus). The three *plates*, epithecal, cingular, and hypothecal, of each valve have not been found parted in any of the specimens examined by us.

The *protoplasmic contents* are hyaline and coarsely granular. The *nucleus*, which is located in the midbody, has a moniliform chromatin reticulum, and is either ellipsoidal, more or less elongated in the major axis of the body, or somewhat irregular. Near the nucleus there is a *pusule*, which opens by a slender canal into the flagellar pore. When present, the *chromatophores* either are small and spherical to ellipsoidal, or they are rather large and cylindrical to rod-shaped (Plate **9**, fig. 6; Plate **11**, fig. 11). In most cases their color appears to be pale yellowish green; sometimes they are brownish or almost colorless. *Metaplasmic inclusions* of different sizes and nature often are found in the cytoplasm. Structures resembling phaeosomes have been found by us only in *Amphisolenia quadrispina*.

The *length of the body* is measured in a straight line from the foremost point of the head to the hindmost point of the antapicals, or, in species with branched antapical, to the hindmost point of the main stem of the antapical. It is a very variable character within the species as well as within the genus. For the genus as a whole the range of variation in length thus far established is 117 μ to 1520 μ.

Reproduction

Binary fission has been observed in a few species. The fission line, or the sagittal suture, has the following course. On the dorsal side of the body: — along the middle of the head, neck, anterior process, midbody, and antapical. On the ventral side of the body: — along the middle of the head, along the left side of the sulcus, crossing the left sulcal list at the fission rib just in front of the flagellar pore, to the left of the flagellar pore and the cytopharyngeal depression, along the middle of the anterior process, midbody and antapical, and in the case of species with branched antapical, along the middle of the antapical branch or branches. In other words, the right valve is slightly larger than the left and includes the whole longitudinal furrow, flagellar pore, and cytopharyngeal depression. The left sulcal list is divided; its anterior, larger part belongs to the left valve, its posterior part, behind the fission rib, belongs to the right valve (Plate **13**, fig. 1, 6, 8). The posterior part of the left sulcal list is not always developed. The fission line

in Amphisolenia thus has about the same morphological course as in other genera of Dinophysoidae in which fission has been studied. It may be noted that while the fission rib is in front of the flagellar pore in Amphisolenia, it is behind this pore in most of the other genera of this tribe, *e.g.*, in Triposolenia, Phalacroma, and Dinophysis.

The cingular and the sulcal lists and the antapical spinules are not resorbed in binary fission (Plate **13**, fig. 1, 6, 8; Plate **11**, fig. 6). Nothing is known as to the time required for the formation of these structures on the new valve. However, the fact that most of the specimens of this genus examined by us had these structures fully developed seems to indicate that the structural differentiation of the new valve takes place rather rapidly. The question as to the time required for the complete development of the antapical spinules of the new valve is, of course, of the greatest importance to the systematist (see *Amphisolenia bidentata* and *A. truncata*). Its solution may throw light on the value of characters utilized in the separation of species in this genus.

It should be noted that what we have termed the accessory sulcal list may possibly be a part of the left sulcal list that is resorbed in binary fission and regenerated after the development of the other parts of the daughter individuals.

In some species the posterior part of the antapical is characterized by what we have interpreted as a hyaline sheath; see *Amphisolenia globifera*, *A. bidentata*, *A. lemmermanni*, and *A. asymmetrica*. The presence of such a sheath is possibly a sign of recent binary fission. The material of this region is possibly associated with the thickening of this part of the thecal wall.

Megacytic stages have not been recorded as yet in Amphisolenia. However, we have established that individuals taken shortly after the separation of the two daughter cells in binary fission are narrower, even in the dorsoventral plane, than other individuals of the same species, and that the dorsoventral width of the midbody is a very variable character (see *A. bidentata* and *A. asymmetrica*). These facts seem to indicate that there is a decrease in the width of the body during binary fission and a gradual increase in the width during the period between two consecutive binary fissions. If such an increase in width does take place, it is doubtless accomplished by means of intercalary growth along the sagittal suture edges of the two valves in the same way as in the megacytic stages of the genera Phalacroma and Dinophysis.

Sexual reproduction has not been observed as yet.

Distribution

A rather large number of writers have contributed to our knowledge of the distribution of the genus Amphisolenia, and the data available are fairly extensive. Unfortunately, only a few of these data are accompanied by drawings or descriptions by means of which the determinations may be checked (see the historical section).

The genus is marine and probably exclusively eupelagic and has a world-wide distribution in tropical, subtropical, and warm-temperate waters. There is no indication of its occurrence outside of waters of tropical, subtropical, or warm-temperate nature or origin.

Most of the species seem to be rare (Hensen, 1911, tab. 13), but occasionally some of them have been found in rather great numbers (see, for instance, Schröder, 1906a, p. 326). Some of the species occur rather frequently in surface waters, but most of them seem to be more or less limited to the deeper levels of photosynthesis (Karsten, 1907, p. 442, 444). However, it should be mentioned, that very few data based on catches made with closing nets are published at the present time. The following closing-net records from Karsten's (1907) report on the phytoplankton of the Valdivia expedition are the only ones published at the present time. *Amphisolenia bidentata* was found, at Station 268, in catches from 17–0 m., 24–4 m., 30–0 m., 63–46 m., and 105–88 m.; all the individuals were reported as "living." *A. palmata* was taken at Station 191; however, the depth recorded, 100–85 m., is indicated as questionable. *A. thrinax* was taken at the following stations: — Station 218, 80–40 m., dead, 80–60 m., living; Station 221, 185–145 m., "tot? doch mit Plasmainhalt"; Station 236, 100–65 m., living; Station 239, 60–45 m., living; Station 268, 21–4 m., living.

Representatives of *Amphisolenia* were found at 78 (61.4%) out of the 127 stations of the Expedition from which dinoflagellates were recorded. These 78 stations are distributed over the whole area covered by the Expedition in the following manner (Plate 26): —

4 (100.0%) out of the 4 stations in the California Current
9 (69.2%) out of the 13 stations in the Mexican Current
7 (41.2%) out of the 17 stations in the Panamic Area
9 (33.3%) out of the 27 stations in the Peruvian Current
7 (70.0%) out of the 10 stations in the Easter Island Eddy
1 (25.0%) out of the 4 stations in the Galapagos Eddy
35 (77.8%) out of the 45 stations in the South Equatorial Drift
3 (100.0%) out of the 3 stations in the South Equatorial Current

2 (100.0%) out of the 2 stations in the Equatorial Counter Current
1 (50.0%) out of the 2 stations in the North Equatorial Current

The numbers of these seventy-eight stations are as follows: 4571, 4574, 4580, 4583 (California Current); 4587, 4588, 4590, 4592, 4594, 4596, 4598, 4605, 4545 (Mexican Current); 4609, 4613, 4617, 4623, 4634, 4638, 4640 (Panamic Area); 4646, 4648, 4650, 4659, 4662, 4666, 4667, 4668, 4676 (Peruvian Current); 4689, 4691, 4694, 4695, 4697, 4699, 4700 (Easter Island Eddy); 4713 (Galapagos Eddy); 4679, 4681, 4683, 4688, 4701, 4705, 4707, 4708, 4709, 4711, 4712, 4717, 4718, 4719, 4720, 4721, 4722, 4723, 4724, 4725, 4727, 4728, 4729, 4730, 4731, 4732, 4733, 4734, 4735, 4736, 4737, 4738, 4739, 4740, 4741 (South Equatorial Drift); 4742, 4743, 4540 (South Equatorial Current); 4541, 4542 (Equatorial Counter Current); 4543 (North Equatorial Current).

At fifty of these seventy-eight stations Amphisolenia was taken in vertical hauls and at thirty-two stations in surface hauls. Most of the records from vertical hauls are from 300–0 fathoms, some are from 800, 150, 100–0 fathoms. Vertical hauls were made at only sixty-eight out of the 127 stations. The genus was thus found at 73.5% of the stations at which vertical hauls were made.

Disregarding the stations at which surface catches only were made, the record stations are distributed over the area covered by the Expedition in the following manner: —

4 (100.0%) out of the 4 stations in the California Current
5 (100.0%) out of the 5 stations in the Mexican Current
5 (83.3%) out of the 6 stations in the Panamic Area
8 (36.3%) out of the 22 stations in the Peruvian Current
5 (100.0%) out of the 5 stations in the Easter Island Eddy
1 (50.0%) out of the 2 stations in the Galapagos Eddy
21 (91.4%) out of the 23 stations in the South Equatorial Drift
1 (100.0%) out of the 1 station in the South Equatorial Current

There were no vertical hauls made in the Equatorial Counter Current or in the North Equatorial Current.

Surface catches and Salpa stomachs of specimens taken in surface waters (81 surface catches and 24 samples of Salpa stomachs) were examined from 82 stations. The genus, as previously mentioned, was taken in surface hauls at thirty-two stations, *i.e.*, at 39.0% of all the surface stations. Taking into consideration the surface stations only, these thirty-two record stations are distributed in the following manner: —

1 (25.0%) out of the 4 stations in the California Current
4 (44.5%) out of the 9 stations in the Mexican Current
3 (23.1%) out of the 13 stations in the Panamic Area

2 (10.0%) out of the 20 stations in the Peruvian Current
2 (40.0%) out of the 5 stations in the Easter Island Eddy)
0 (0.0%) out of the 2 stations in the Galapagos Eddy
15 (65.2%) out of the 23 stations in the South Equatorial Drift
2 (100.0%) out of the 2 stations in the South Equatorial Current
2 (100.0%) out of the 2 stations in the Equatorial Counter Current
1 (50.0%) out of the 2 stations in the North Equatorial Current

The numbers of these thirty-two surface stations are as follows: 4583 (California Current); 4588, 4592, 4596, 4545 (Mexican Current); 4623, 4638, 4640 (Panamic Area); 4648, 4676 (Peruvian Current); 4694, 4700 (Easter Island Eddy); 4688, 4708, 4712, 4718, 4720, 4723, 4725, 4727, 4729, 4731, 4733, 4735, 4738, 4740, 4741 (South Equatorial Drift); 4743, 4540 (South Equatorial Current); 4541, 4542 (Equatorial Counter Current); 4543 (North Equatorial Current).

On account of the prevalence of Amphisolenia in deeper waters, the table showing the distribution and the frequency of the record stations at which the genus was found in *vertical* hauls is probably a better indicator of the horizontal distribution of this genus in the area investigated by the Expedition than is the table in which all the record stations are included. The fifty stations at which Amphisolenia was taken in vertical hauls are scattered over the whole area covered by the Expedition (Plate 26). In the California Current, Mexican Current, Easter Island Eddy, and South Equatorial Current the genus occurred at all the stations at which vertical hauls were made and in the Panamic Area and the South Equatorial Drift at 83.3% and 91.4%, respectively, of the stations with vertical hauls. In the Peruvian Current, on the other hand, the genus occurred at only 8 (36.3%) out of the 22 stations with vertical hauls. If the number of records of species is considered, we find a strikingly small number of records of species of Amphisolenia in the relatively cool Peruvian Current and in the portion of the South Equatorial Drift that is under the direct influence of this current but a remarkably large number of records in the Easter Island Eddy and in the western and middle portions of the South Equatorial Drift. For a discussion of these data and a comparison between the horizontal distribution of Amphisolenia and that of Triposolenia, see the section on the distribution of Triposolenia.

Amphisolenia is most frequent in surface catches in the South Equatorial Drift, South Equatorial Current, and the Equatorial Counter Current. It was found very seldom at the surface in the Peruvian Current.

There are 210 records of species of Amphisolenia from vertical catches. Out of these 210 records, 1 (0.5%; Station 4648) showed a frequency of 8%; 1 (0.5%;

Station 4739) showed 6%; 3 (1.4%; Stations 4713, 4719, 4740) showed 4%; 6 (2.9%; Stations 4587, 4590, 4689, 4697, 4728, 4737) showed 3%; 10 (4.8%; Stations 4583, 4590, 4638, 4659, 4701, 4717, 4721, 4724, 4734, 4736) showed 2%; 43 (20.5%; Stations 4571, 4574, 4580, 4583, 4590 [2 records], 4594, 4598, 4605, 4609, 4613 [2 records], 4617 [2 records], 4638, 4646, 4662, 4666, 4667, 4668 [2 records], 4683, 4689, 4691 [2 records], 4695, 4699, 4701 [2 records], 4707, 4709, 4713, 4717 [2 records], 4719, 4721, 4722, 4730, 4732 [2 records], 4737, 4739, 4742) showed 1%; 146 (69.5%) showed a frequency of less than 1%.

There are 42 records of species of this genus from surface catches. Out of these 42 records, 4 (9.5%; Stations 4592, 4720, 4725, 4741) showed a frequency of 2%; 12 (28.6%; Stations 4596, 4638, 4640, 4648, 4676, 4688, 4712, 4718, 4731, 4738, 4743, 4543) showed 1%; 26 (61.9%) showed a frequency of less than 1%.

Coincident occurrence of different species of Amphisolenia in catches from 300 (800, 150)–0 fathoms is recorded at the following of the fifty stations mentioned above: 12 species occurred coincidently at 1 station (2.0%; Station 4737); 11 species at 1 station (2.0%; Station 4701); 9 species at 2 stations (4.0%; Stations 4739, 4740); 8 species at 3 stations (6.0%; Stations 4732, 4734, 4736); 7 species at 4 stations (8.0%; Stations 4587, 4605, 4699, 4728); 6 species at 5 stations (10.0%; Stations 4691, 4713, 4722, 4724, 4742); 5 species at 3 stations (6.0%; Stations 4583, 4590, 4697); 4 species at 4 stations (8.0%; Stations 4594, 4613, 4617, 4668); 3 species at 9 stations (18.0%; Stations 4580, 4634, 4667, 4695, 4709, 4711, 4717, 4719, 4721); 2 species at 11 stations (22.0%; Stations 4574, 4598, 4638, 4659, 4662, 4679, 4681, 4689, 4705, 4707, 4730).

Coincident occurrence of different species of this genus in surface catches is recorded at the following of the thirty-two surface stations mentioned above:— 3 species occurred coincidently at 2 stations (6.3%; Stations 4733, 4741); 2 species at 6 stations (18.8%; Stations 4588, 4700, 4720, 4723, 4725, 4743).

It should be noted that out of the twenty-four surface catches in each of which only one species of Amphisolenia was found, not less than twenty contained *A. bidentata*. Other species of this genus than *A. bidentata* thus were found at only twelve out of the thirty-two surface record stations. *A. bidentata* was found at no less than twenty-eight out of these thirty-two surface stations. This indicates that of all the known species of this genus, *A. bidentata* is by far the most common in surface waters. Karsten (1907, p. 442) writes as follows: "Amphisolenia dürfte in ihren gewöhnlicheren Arten *palmata* und *bidentata* der Oberfläche angehören, dagegen ist *A. thrinax* Schütt häufiger in den tiefer gehenden Fängen wahrgenommen." Besides *A. bidentata* only the following species of this

genus were found in surface catches: — *A. lemmermanni* (four stations), *A. schauinslandi* (three stations), *A. thrinax* (three stations), *A. palmata* (two stations), *A. globifera* (one station), and *A. truncata* (one station). Out of these six species *A. lemmermanni* and *A. palmata* are very closely related to *A. bidentata*.

Our records show that a great number of species of this genus may occur within a comparatively small area. Indeed, out of the twenty-seven possibly valid species of this genus known at the present time, not less than twenty-six have been found in the material of the Expedition. It seems rather improbable that the region investigated by us is unique in this respect. The fact that only seven species of this genus have been found in regions outside of the tropical and subtropical parts of the Eastern Pacific, although some of the previous investigators have had rather rich material of tropical and subtropical plankton at their disposal, seems to indicate that, at least in some cases, we should accept the published data on the distribution of the species of this genus with a certain reservation. However, it should be remembered that most writers who have treated this genus have had surface catches only at their disposal.

Historical Discussion

The genus Amphisolenia was established by Stein (1883, p. 24), who founded it on two new species, *A. globifera* and *A. palmata*. These two species were figured by Stein without any generic or specific diagnoses or descriptions. The first diagnosis of Amphisolenia was published by Bütschli (1885, p. 1010). It is very short and incomplete and is evidently based on Stein's (1883) drawings. Diagnoses of this genus have been published also by Schütt (1896, p. 28), Delage and Hérouard (1896, p. 385), Paulsen (1908, p. 20), and Willey (1909, p. 187). No thoroughgoing description and discussion of the genus have yet been published.

Besides the two species mentioned in the previous paragraph, the following species of Amphisolenia are to be found in the literature: — *A. thrinax* and *A. tripos* Schütt (1893), *A. bifurcata* and *A. inflata* Murray and Whitting (1899), *A. schauinslandi* Lemmermann (1899a), *A. bidentata* Schröder (1900a), *A. asymmetrica, A. bispinosa, A. brevicauda, A. clavipes, A. curvata, A. dolichocephalica, A. extensa, A. laticincta, A. lemmermanni, A. palaeotheroides, A. projecta, A. quadrispina, A. quinquecauda, A. rectangulata*, and *A. schröderi* Kofoid (1907a), *A. spinulosa* Kofoid (1907b), *A. astragalus, A. quadricauda*, and *A. truncata*

Kofoid and Michener (1911), *A. tridens* Gräf (1909), *A. furca* Hensen (1911), and *A. tenella* Gran (1912b). Thus thirty species of this genus were established before the publication of the present paper. In addition to these, two new species, *A. elongata* and *A. complanata* are described in this paper. In other words, not less than thirty-two species of Amphisolenia are named at the present time.

However, a number of these thirty-two species undoubtedly must be discarded. *Amphisolenia tripos* (Schütt, 1893, p. 299; Hensen, 1911, p. 159, 160), *A. furca* (Hensen, 1911, p. 159, 160), and *A. tridens* (Gräf, 1909, p. 173, 179, 192) were introduced into the literature as *nomina nuda*, and there is as yet no information published as to their organization. Kofoid (1906c, p. 93) suggests that *A. tripos* may refer to a species of the genus Triposolenia. *Amphisolenia bidentata* and *A. lemmermanni* are so similar that their specific separation must be regarded as tentative. The specific separation of *A. bidentata* and *A. palmata* also must be regarded as problematical. We regard *A. dolichocephalica* as a synonym of *A. asymmetrica*. *A. schröderi* and *A. clavipes* may represent giant and dwarf phases in a cytogenetic complex. The same is true in the case of *A. extensa* and *A. elongata*. *A. truncata* may be a representative of *A. complanata* in which the antapical spinules have not yet developed following binary fission, and *A. tenella* possibly may be synonymous with *A. globifera*. The question as to whether or not *A. projecta* is a valid species cannot be settled as yet. The type specimen of this species possibly may be a representative of *A. bifurcata* in which the dorsal antapical limb is broken.

As will be seen from the last paragraph, our knowledge of the separation and characterization of the species of Amphisolenia is still uncertain and tentative. All the descriptions of species published up to the present writing are short and incomplete and do not have data of variations for consideration. The descriptions published by Kofoid (1907a) and Kofoid and Michener (1911) are preliminary and based on the same material as those of the present paper.

Schröder (1900a, p. 20) divided Amphisolenia into two groups, viz., Simplices and Incisae. In the first group were included *Amphisolenia globifera*, *A. inflata*, *A. bidentata*, *A. palmata*, and *A. schauinslandi;* the second group comprised *A. bifurcata*, *A. tripos*, and *A. thrinax*.

A few remarks as to the adaptive value of the peculiar shapes of the body of the species of this genus have been made by the following writers: — Schütt (1893, p. 273), Kofoid (1906e, p. 133), Zacharias (1906, p. 563), Steuer (1910, p. 196), Carisso (1911, p. 89), Hjort (1911), Gran (1912 a and b), and Oltmanns (1923, p. 327).

Hensen (1911, p. 160, 161) discussed the systematic value of structural differences.

Contributions to our knowledge of the distribution of Amphisolenia are to be found in the following papers, not specifying those in which new species are described: — Hensen (1895), Cleve (1897a, 1900b, 1901a, 1901c, 1902b, 1903b), Schröder (1900b, 1906a, 1906b, 1909, 1911), Ostenfeld and Schmidt (1901), Schmidt (1901), Lemmermann (1901a, 1904, 1905a, 1908b), Ostenfeld (1902, 1915), Entz (1902b, 1905), Ostenfeld and Paulsen (1904), Zacharias (1906), Karsten (1906, 1907), Okamura (1907, 1912), Stüwe (1909), Schiller (1911a, 1912), Pavillard (1916), Forti (1922), Jörgensen (1923), and Lindemann (1924). Of these papers only those of Okamura (1907, 1912) and Jörgensen (1923) contain drawings by which the accuracy of the determinations may be judged. Forti (1922) gives reproductions of the original drawings of the type specimens. Some of the data on the distribution of this genus undoubtedly should be accepted with reservations.

Other papers in which problems of morphology, etc., in Amphisolenia are treated, are as follows: — Chun (1903), Kofoid (1906c), Doflein (1909, 1911, 1916), Hjort (1911), Gran (1912a), and West (1916).

Adaptive and Systematic Value of the Characters. Principles used in the Description of the Species

The genus Amphisolenia, as previously mentioned, is confined to waters of tropical, subtropical, and warm-temperate nature or origin; in other words, to waters of comparatively low viscosity. The relatively low buoyancy of these waters is clearly reflected in the general organization of the genus. Amphisolenia belongs to the group of plankton organisms in which the floating capacity has been increased "durch Streckung des Körpers in einer Richtung und Ausbildung der Stabform" (Steuer, 1910, p. 190, 196). In the species of the Bifurcata group the surface of resistance to the downward movement has been further increased by the asymmetrical branching of the posterior part of the antapical.

The interpretation, made by Kofoid (1906e), of the asymmetry in Triposolenia also applies, *mutatis mutandis*, to Amphisolenia (Kofoid, 1906e, p. 133). In Amphisolenia, some species are almost straight, but generally the longitudinal axis of the body has a slight or moderate sigmoid curvature, with the neck somewhat deflected dorsally and the antapical having a more or less pronounced ventral concavity. In most species of this genus the head is inclined anteriorly, and

sometimes the posterior part of the antapical is bent ventrally or to the right at an angle of 25°–50°. In the species of Amphisolenia with a branched antapical, the antapical stem is often characterized by a more or less striking sigmoid curvature in the dorsoventral plane; in other words, the longitudinal axis of the body may have a double sigmoid curvature. Sometimes the modifications in the longitudinal axis of the body are accompanied by torsion. When these peculiarities in Amphisolenia are studied in the light of Kofoid's (1906e) interpretation of the asymmetry in Triposolenia, their adaptive value is readily understood.

Gran's (1912b, p. 327) assumption that the antapical knob in *Amphisolenia globifera* is adaptive, inasmuch as it brings about a balanced condition of the body, seems rather plausible. Furthermore, the balanced condition of the body is a striking characteristic of several species of this genus, as for example in *A. inflata*, *A. schauinslandi*, and *A. schröderi*. In *A. inflata*, whose antapical on the one hand, and head, neck, and anterior process on the other, are well balanced, the center of gravity of the organism is in the middle of the large, regularly ovoidal midbody. Similar conditions are to be found in *A. schauinslandi* and *A. schröderi*. On the other hand, in *A. brevicauda*, whose relatively long neck and large head outweigh the very short antapical, the center of gravity of the organism is behind the middle of the midbody. Reference is also made to Plate 12, figure 6, of *A. thrinax* in which the posterior branches and enlarged posterior region modify the balance.

The asymmetry which frequently is found in the sulcal lists about the flagellar pore may be considered as adaptive; it favors a progressive dexiotropic movement of the organism (Kofoid, 1906e, p. 129).

Schütt (1893, p. 273) writes as follows: "Uebrigens wirkt die Körperverlängerung durch die häufig an den Hörnern angebrachten Stacheln auch direkt als Waffe, wie z. B. bei Amphisolenia." We know little, however, of the selective utilization of the microplankton by plankton-feeding organisms.

According to Hensen (1911, p. 160) the genus Amphisolenia is a "biological" unit. He considers it improbable that any "important biological value" can be attached to the structural differences in the antapical, on which most of the species have been established and "die durch keine oder jedenfalls äusserst seltene Uebergangsformen gestört wird." "Solange solche Unwahrscheinlichkeit bei sich sonst sehr nahe stehenden Arten bestehen bleibt, ist es mir richtig, sie als biologisch nicht trennbar zu behandeln."

The existence of "systematisch gut scheidbare Besonderheiten der Anzahl und des Vorkommens" Hensen (1911, p. 160, 161) considers in the light of the

following possibilities: — the "variety" is (*1*) dying out, (*2*) originating, (*3*) an abnormality, (*4*) a seasonal variation, (*5*) a temperature variety, (*6*) a life-cycle variation, (*7*) a geographical variety,(*8*) a sport, (*9*) a relic, or (*10*) senile. The first two possibilities he rejects because "es sich dabei um mindestens drei Arten handelt und diese Arten noch weit verbreitet sind. Für solchen Fall müsste eine enge Verbreitung postuliert werden." The third possibility is rejected because abnormalities are easily recognized as such and, furthermore, are not constant. The fourth is also rejected, seasonal changes being very slight in the warm regions of the sea, where the genus occurs. The fifth possibility is left open. "Einflüsse der Wasserwärme könnten vermutet werden, da *A. tripos* das etwas kühlere Gebiet des Südarms des Golfstroms bevorzugt." The possibility (*6*) of life-cycle variation, *i.e.*, of cyclic polymorphism, Hensen does not reject *a priori*, because of the conditions in *Ceratium tripos*. The rare occurrence of three out of the four species could thus be accounted for. "Für den Vorgang fehlt zurzeit noch das Verständnis, indessen kann gesagt werden, dass die polymorphen Gestaltungen von *Ceratium tripos* soweit von der Mutterform abweichen, wie es den geringen Formverschiedenheiten der Amphisolenien nicht entspricht." The seventh possibility is rejected because the distributional data brought together by the Plankton Expedition do not conform to the distribution that, according to the author, would result from this mode of origin. The eighth possibility is rejected for two reasons: — "Für Zufallsvarietäten kann ein besonders gutes Gedeihen nicht erwartet werden." "Wenn der Zufall Erzeuger ist, scheint gefordert werden zu müssen, dass gleichzeitig viele Uebergänge gefunden werden, was aber nicht der Fall ist." An attempt to explain the absence of transitional forms by the assumption that these forms either are unable to maintain themselves or that they revert to the original type and that only "die vollendeten Formen" survive would necessitate the further assumption "dass die Zelle selbst und nicht nur der Stiel Modifikationen erlitten habe, die das Bestehen der Art sichern." The ninth possibility, *i.e.*, that we are concerned with relics from "the time when the polar waters were warm," is not considered as excluded. However, "es ist bemerkenswert, dass bei dieser Annahme die selteneren Arten nicht, wie bisher als die jüngeren, sondern als die älteren erscheinen, daher *A. palmata* als die jüngere und zugleich als die best angepasste aufzufassen wäre." The tenth possibility, "dass die Formen der *Amphisolenia palmata* sich mit dem Altern der Zellen verändern," is also left open. "In dieser Richtung liegen für die Peridiniales meines Wissens bisher keine Beobachtungen vor, aber das beweist noch nicht die Unmöglichkeit solchen Verhaltens, nur müssten sich dann viele Uebergänge finden."

As will be seen from the above summary, Hensen rejects six out of the ten discussed possible explanations for the existence of the established "systematisch gut scheidbare Besonderheiten der Anzahl und des Vorkommens." The four remaining possibilities, viz., (*5*) that the morphological differences observed are temporary (?) and due to changes in temperature, (*6*) due to cyclic polymorphism, (*9*) related to conditions in prequaternary times, or (*10*) due to senile changes of the cells of a single species, *Amphisolenia palmata*, are neither accepted nor rejected.

According to our opinion, Hensen's discussion of diversity of form in Amphisolenia is based upon an inadequate study of the species and their distinctive characters and on untenable considerations of the problem of structural changes as related to reproductive and ecological phenomena. He appears to have confused the ontogenetic and the phylogenetic development. His opinion that this genus is a "biological" unit also appears to be untenable in the light of the differences which we have found in the vertical and horizontal distribution of the species.

The characters by which the species of Amphisolenia have been distinguished from each other in the present paper are principally the size of the body, the shape of the longitudinal axis of the body, the shape and inclination of the head, the relative length and width of the neck, the shape and relative length and width of the midbody, the curvature and relative length and width of the antapical, the number of antapical branches, and the structure of the posterior end of the antapical. Pronounced structural differentiation of the thecal wall appears only in *Amphisolenia inflata* among the known species of this genus.

A comparatively high systematic value has been attributed by us to the shape and structure of the posterior part of the antapical. Indeed, most of the systematic subdivisions of the genus as established in this paper, *e.g.*, the GLOBIFERA group and the PALMATA group, are based largely on the type of this part of the body. Another character to which high systematic value has been attached is the branching of the posterior part of the antapical. On the basis of this characteristic the BIFURCATA group has been established.

As many characters as possible should be taken into account in the establishment of the species. In most cases several characters are required for certainty in the identification of species. Exceptions from the last-mentioned rule, which is well illustrated by the key to Amphisolenia given in this paper, are, as far as our present knowledge goes, *A. inflata*, *A. laticincta*, *A. brevicauda*, *A. asymmetrica*, and the species of the BIFURCATA group.

Our knowledge of the separation and characterization of the species of Amphisolenia is still uncertain and tentative. The main reason for this uncertainty is that almost all characters are subject to fluctuations in different degrees of amplitude. No extensive investigation of the variability of the individual characters has as yet been carried out. Another reason is that nothing is known as to the time required, following binary fission, for the complete development of the antapical spinules of the new valve (see *A. bidentata* and *A. truncata*).

The variations in the relative width of the body may result in part from two factors: — first, a decrease of the width as a result of binary fission and, second, a gradual increase of the width during the period between two consecutive fissions (see the section on the reproduction of the genus).

In the case of several species the narrowness of the body makes it difficult to determine the degree of tilting of a specimen examined under the microscope. Pressure exerted on the cover-glass in order to bring a specimen into a desired position is likely to shift the angle of presentation and thus to modify the outline of the asymmetrical body as seen by the observer (Figure 48). The variations in the shape and inclination of the head and in the width and shape of the midbody in some species as presented in this paper probably to some extent are apparent and due to the tilted positions of some of the specimens examined.

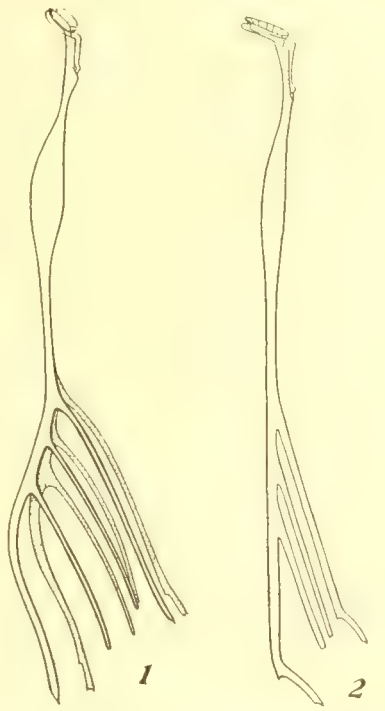

FIGURE 48.— *Amphisolenia quadricauda* Kofoid. 1, right lateral view, showing parting of valves of antapical; head somewhat tilted; 2, sublateral view of specimen represented by 1, showing result of pressure and tilting on width of midbody, shape of antapical stem, and shape and relative lengths of antapical branches, as seen by observer. Type specimen. Station 4695 (300–0 fathoms). × 125.

The following principles have been used by us in describing the species of this genus: —

(*1*) When not otherwise stated, all characteristics refer to specimens in lateral view.

(*2*) In describing the proportions of the body, the length of the neck, measured in a straight line from the posteroventral point of the head to the flagellar pore (Figure 47), has been used as a unit.

(*3*) The methods of measuring lengths, proportions, and angles used in this paper are shown in Figure 47.

(*4*) The lengths of the antapical branches, in contrast to the lengths of the other parts of the body, are not measured in straight lines but are measured along the curvatures from the midpoints of the bases of the branches to the tips.

(*5*) The thecal wall is without structure in all the species in whose diagnoses this character is not mentioned.

(*6*) The antapical is unbranched in all the species in whose diagnoses this character is not mentioned.

(*7*) In the species with branched antapical the anterior antapical branch is called the first branch, the next one the second, and so on.

Subdivisions. Relationships among the Species

Schröder (1900a, p. 20), who is the only writer to attempt a subdivision of the genus Amphisolenia, established two groups: "A. Simplices. Hinteres Ende unverzweigt, kugelig oder mit 2–4 Stacheln: *globifera, inflata, bidentata, palmata, schauinslandii;* B. Incisae. Hinteres Ende getheilt, doppelt oder dreifach gegabelt: *bifurcata, tripos* und *thrinax.*"

Incisae probably represent a natural systematic unit. Simplices, on the other, hand, comprise rather heterogeneous elements, and its subdivision is highly desirable. On account of the incompleteness of the data available, such a subdivision encounters great difficulties. Our attempt should be regarded as tentative rather than as final. According to our opinion, the twenty-seven possibly valid species of *Amphisolenia* may be divided as follows: —

1. Species of uncertain, or of more or less isolated position: — *A. inflata, A. laticincta, A. brevicauda, A. schauinslandi, A. rectangulata, A. astragalus* and *A. spinulosa.*

2. Extensa group: *A. extensa* and *A. elongata.*

3. Globifera group: *A. globifera* and *A. quadrispina.*

4. Bispinosa group: *A. bispinosa* and *A. curvata.*

5. Schröderi group: *A. schröderi, A. clavipes, A. complanata,* and *A. truncata.*

6. Palmata group: *A. bidentata, A. lemmermanni, A. palmata, A. palaeotheroides,* and *A. asymmetrica.*

7. Bifurcata group (Incisae Schröder): *A. bifurcata, A. projecta, A. thrinax, A. quadricauda,* and *A. quinquecauda.*

In the following will be given a short characterization and discussion of these species and groups: —

1. Species of uncertain or more or less isolated position. *Amphisolenia inflata.* This species occupies a rather isolated position and is probably

more primitive than any other known species of its genus. The following characters separate it from other members of its genus: — (*1*) the decided concavity of the anterior face of the epitheca; (*2*) the well set off anterior process; (*3*) the relatively large and bilaterally compressed midbody; (*4*) the very distinct structural differentiation of the thecal wall; (*5*) the structures of the cingular and sulcal lists. With regard to characters indicating primitiveness and close relationship to *Triposolenia truncata*, see the section on the subdivisions of the family Amphisolenidae and the section on the comparisons of this species.

Amphisolenia laticincta. This species also occupies a rather isolated position. The narrowness of the head and the wideness of the transverse furrow, as well as the simple, rounded antapex give it an exceptional appearance. The small size, the straight longitudinal axis of the body, the rather well-developed midbody set off from the antapical, and the very simple, unbranched antapical seem to indicate that this species is fairly low in the scale of the evolutionary development of the genus.

Amphisolenia brevicauda. The peculiar asymmetry of the midbody, the relative shortness of the antapical, and the simple, pointed antapex place this species also in a rather isolated position. The small size of the body and the simple, unbranched antapical well set off from the midbody appear to be primitive features. The species may possibly be a representative of an evolutionary branch that split off at a fairly early stage in the phylogenetic differentiation of the genus, and in which the tendency to posterior elongation has been inhibited.

Amphisolenia schauinslandi. The systematic position of this species is uncertain. The anterior process, which is relatively longer than in any other known species of this genus, gives to the species a rather unique appearance. The shape and the structure of the posterior end of the antapical are suggestive of *A. rectangulata.* The straight longitudinal axis of the body, the fairly well-developed midbody which in most specimens is rather distinctly set off from the antapical, and the simple, unbranched antapical appear to be primitive features of this species.

Amphisolenia rectangulata. The systematic position of this species is also uncertain. The shape and the structure of the posterior part of the antapical recall *A. schauinslandi.* The simple, unbranched type of the antapical appears to be a primitive feature, but in most other respects this species probably is rather highly differentiated.

Amphisolenia astragalus. The systematic position of this highly differentiated species is unknown. The abrupt ventral bending of the posterior foot-like

part of the antapical is a characteristic of this species, which is not found in any other member of the genus. The single distal spinule and the rounded lateral protuberance contribute to the peculiar appearance of the posterior part of the antapical; see also the discussion of this species.

Amphisolenia spinulosa. No well-founded suggestion as to the systematic position of this species can be given as yet, due to our lack of knowledge of the relation of the antapical spinules to the thecal valves. The deflection to the right of the posterior portion of the antapical and the presence of three spinules on the antapex suggest relationship to the PALMATA group. However, the species of this group always are characterized by a strong lateral spinule, the heel-spinule, located on the left valve at some distance from the antapex, and such a spinule is not developed in *A. spinulosa*. On the other hand, the proportions, the curvature of the antapical, and the weakness of the antapical spinules indicate relationship to the EXTENSA group; indeed, *A. spinulosa* and *A. elongata* are of about the same habitus.

2. EXTENSA group. This group is characterized by the great elongation of the antapical, by the club-shaped posterior portion of the antapical and the subtruncate antapex, and by the slight development of the antapical spinules. The simple, unbranched type of the antapical appears to be a primitive feature of the group. On the other hand, the more or less pronounced sigmoid curvature of the longitudinal axis of the body, the slenderness of the midbody, the tendency of the midbody to merge into the antapical, and the excessive elongation of the antapical probably are advances in differentiation.

3. GLOBIFERA group. The posterior portion of the antapical is knob-like; just in front of the knob, there is, in most cases, a short, neck-like constriction. The straight longitudinal axis of the body and the unbranched antapical appear to be primitive features of this group. The gradual merging of the midbody into the antapical, and the differentiation of the posterior portion of the antapical probably are later acquisitions.

4. BISPINOSA group. This group is characterized by the sigmoid curvature of the longitudinal axis of the body (most strikingly developed in *A. curvata*), by the bilateral position of the two spinules on the antapex, one spinule on each valve, and by the longitudinal ridges on the neck. The simple, unbranched type of the antapical appears to be a primitive feature of this group. The gradual merging of the midbody into the antapical and the sigmoid curvature of the longitudinal axis of the body probably are advances in differentiation.

5. SCHRÖDERI group. The characterization of this group is rather diffi-

cult. The species exhibit a general similarity in several characters rather than a close agreement in a few features. The midbody is fusiform, slender, and merges very gradually into the anterior process and into the midbody. The posterior portion of the antapical shows a tendency to become bent to the right; the bending is slight in *A. complanata* and *A. schröderi*, very striking in some specimens of *A. clavipes;* in *A. truncata* the posterior part of the antapical is straight. The antapex has two sagittal spinules, except in *A. truncata* in which no spinules are developed (see the discussion of this species); both of these antapical spinules probably belong to the left valve; this asymmetry is the most striking characteristic of the group. The chromatophores probably always are large and rod-shaped. The straight longitudinal axis of the body and the simple, unbranched type of the antapical appear to be primitive features of this group. The slenderness and the very gradual merging of the midbody into the antapical are probably advances in differentiation. *A. schröderi* and *A. clavipes* probably are more closely related to each other than to the two remaining species of this group. *A. complanata* and *A. truncata* are probably also very close relatives.

6. Palmata group. The posterior part of the antapical is asymmetrical and bent to the right. At the point of bending the left valve has a rather strong, pointed spinule, the heel-spinule. The antapex is truncate and more or less inflated, and has either two or three spinules. When only two spinules are present, both of them belong to the left valve and are placed near the suture. When three spinules are developed, the additional spinule belongs to the right valve and is placed between the two spinules of the left valve. The unbranched antapical is a primitive feature of this group. The slight sigmoid curvature of the longitudinal axis of the body, the gradual merging of the midbody into the antapical, and the differentiation of the posterior part of the antapical probably are later acquisitions. Of the five species that belong to this group, *Amphisolenia bidentata* and *A. lemmermanni* have only two spinules on the antapex. The fact that in the Schröderi group the antapex probably has the same number and arrangement of spinules appears to indicate that this is the more primitive condition. *A. asymmetrica*, which is characterized by a unique and peculiar shape of head, occupies a somewhat isolated position within the group.

7. Bifurcata group (Incisae Schröder). The head is three to four times wider than long and inclined anteriorly at an angle of 20°–30°; the epitheca is flat or gently convex. The midbody is fusiform, rather narrow or of moderate width and merges gradually into the anterior process and into the antapical. The posterior part of the antapical has one to four branches. The distal portion of the

main antapical stem and of the first antapical branch have about the same shape and structure as in *Amphisolenia palmata;* in other words, the left valve has a heel-spinule at some distance from the tip, and the tip has three spinules, two on the left valve and one on the right valve. When two to four antapical branches are developed, all the branches except the proximal one lack the heel-spinule. *A. bifurcata*, *A. thrinax*, *A. quadricauda*, and *A. quinquecauda* form an orthogenetic series of an increasing number of ventral branches, the smallest and presumably the youngest phylogenetic addition being interpolated at the posterior end of the series of branches. It is possible that the series lies within a single variable species. In the absence of known sexual reproduction and in view of the seeming necessities in skeletal completion at binary fission, we treat the units of the series as species.

The EXTENSA, GLOBIFERA, BISPINOSA, SCHRÖDERI, and PALMATA groups should not be considered as subdivisions of Schröder's SIMPLICES but as units of the same systematic value as his INCISAE (the BIFURCATA group).

To attribute subgeneric value to the groups established above is avoided since our knowledge of the genus is still rather incomplete, and, as mentioned previously, the classification suggested should be regarded as tentative rather than as final.

With regard to the relationships of these groups, we are unable to contribute anything but a few suggestions. The EXTENSA, GLOBIFERA, and BISPINOSA groups are small, and seem to occupy rather isolated positions; an attempt to settle their relationships at the present time would be premature. The SCHRÖDERI, PALMATA, and BIFURCATA groups, on the other hand, appear to form a phylogenetic series of orthogenetic facies in which the SCHRÖDERI group probably represents the most primitive and the BIFURCATA group the most advanced stage. This supposition is based mainly on the shape and structure of the posterior portion of the antapical. In *Amphisolenia schröderi* and *A. clavipes* the posterior portion of the unbranched antapical is bent to the right; on the antapex there are two sagittal spinules, both probably belonging to the left valve; no heel-spinule is developed. In the PALMATA group the posterior part of the unbranched antapical is bent to the right; at the point of bending the left valve has a heel-spinule. The antapex has either two or three spinules; when only two spinules are present, both of them belong to the left valve and are placed near the suture; when three spinules are developed, the additional spinule belongs to the right valve and is placed between the two spinules of the left valve. In the BIFURCATA group the antapical is branched and its posterior end has the same shape and structure as in *A. palmata.*

No characters are known that do not harmonize with the assumption that these three groups form a phylogenetic series marked by increasing complexity in the antapical region.

On account of the uncertainty as to the systematic positions of the species mentioned in the first group and of the EXTENSA, GLOBIFERA, and BISPINOSA groups, we are unable to reconstruct as yet the phylogenetic development of the genus Amphisolenia.

Key to the Species of Amphisolenia

1. Antapical not branched ..... 2.
1. Antapical branched ..... (BIFURCATA group) 23.
2. Posterior part of antapical with crude resemblance to foot; its valves asymmetrical; the left with three spinules, one, the "heel-spinule," at some distance from antapex and two on antapex; the right with one spinule on antapex or without spinules ..... (PALMATA group) 19.
2. Posterior part of antapical not foot-shaped, except in *A. astragalus;* left valve of antapical without "heel-spinule" ..... 3.
3. Epitheca quite concave; thecal wall profusely and strikingly pitted. . *inflata* Murray and Whitting.
3. Epitheca convex or more or less flattened; thecal wall structureless or almost so ..... 4.
4. Width of transverse furrow exceeds dorsoventral diameter of head; head about twice longer than wide ..... *laticincta* Kofoid.
4. Width of transverse furrow less than dorsoventral diameter of head; head about as wide as or wider than long ..... 5.
5. Dorsal margin of midbody almost straight, ventral margin with well-developed convexity; antapical shorter than neck; antapex pointed, without spinules ..... *brevicauda* Kofoid.
5. Midbody and antapical of other types ..... 6.
6. Antapical about as long as or slightly shorter or longer than anterior process and midbody; its posterior part straight, expanding to a knob-like termination; generally with neck-like constriction just in front of knob ..... 7.
6. Antapical of other types ..... 8.
7. Antapex with none to two spinules ..... *globifera* Stein.
7. Antapex with four spinules ..... *quadrispina* Kofoid.
8. Antapical 2–7 times longer than anterior process and midbody; its posterior part straight, somewhat club-shaped, subtruncate; antapical spinules, if present, exceedingly small, hardly distinguishable . 9.
8. Antapical of other types ..... 10.
9. Antapical 4–7 times longer than anterior process and midbody; length of body, 1292–1520 μ. *extensa* Kofoid.
9. Antapical 2–3 times longer than anterior process and midbody; length of body, 438–464 μ. *elongata*, sp. nov.
10. Antapex with four spinules, two on each valve ..... 11.
10. Antapex with less than four spinules ..... 12.
11. Antapical shorter than anterior process and midbody ..... *schauinslandi* Lemmermann.
11. Antapical about twice as long as anterior process and midbody ..... *rectangulata* Kofoid.
12. Antapex with three spinules ..... *spinulosa* Kofoid.
12. Antapex with less than three spinules ..... 13.
13. Posterior part of antapical foot-shaped, bent ventrally, with one distal spinule and one lateral rounded protuberance ..... *astragalus* Kofoid and Michener.
13. Posterior part of antapical of other types ..... 14.
14. Longitudinal axis of body with more or less pronounced sigmoid curvature; antapical spinules, if present, lateral in position, one on each valve ..... 15.
14. Longitudinal axis of body straight or with but slightly developed sigmoid curvature; antapical spinules, if present, sagittal in position (belonging to left valve?) ..... 16.
15. Antapical spinules comparatively strong; ratio between length and greatest width of body, 35–40: 1. *bispinosa* Kofoid.

15. Antapical spinules, if present, very small; ratio between length and greatest width of body, 12–13: 1. *curvata* Kofoid.
16. Antapical without spinules ..... *truncata* Kofoid and Michener.
16. Antapical with two spinules ..... 17.
17. Head about three times wider than long ..... *complanata*, sp. nov.
17. Head spheroidal, about as long as wide ..... 18.
18. Length of body, 230–263 μ; posterior part of antapical more or less strongly bent to the right. *claviper* Kofoid.
18. Length of body, about 510 μ; posterior part of antapical but slightly bent to the right. *schröderi* Kofoid.
19. Antapex with two spinules; right valve without antapical spinule ..... 20.
19. Antapex with three spinules; right valve with one antapical spinule ..... 21.
20. Length of body, 716–990 μ; ratio between length and greatest width of body, 30.3–67.1: 1. *bidentata* Schröder.
20. Length of body, 522–669 μ; ratio between length and greatest width of body, 13.4–33.8: 1. *lemmermanni* Kofoid.
21. Head 9–10 times wider than long ..... *asymmetrica* Kofoid.
21. Head about 1.5–3.0 times wider than long ..... 22.
22. Antapical 1.5–2.3 times longer than anterior process and midbody ..... *palmata* Stein.
22. Antapical shorter than anterior process and midbody ..... *palaeotheroides* Kofoid.
23. Antapical with one branch ..... 24.
23. Antapical with more than one branch ..... 25.
24. One of the antapical limbs strikingly shorter than the other, clavate, without spinules. *projecta* Kofoid.
24. Antapical limbs subequal, both with spinules ..... *bifurcata* Murray and Whitting.
25. Antapical with two branches ..... *thrinax* Schütt.
25. Antapical with three branches ..... *quadricauda* Kofoid and Michener.
25. Antapical with four branches ..... *quinquecauda* Kofoid.

1. Species of Uncertain or More or Less Isolated Position. Out of the seven species that belong to this group, six have been found in the material of the Expedition. These six species have been treated in the following order, which is partly indicative of their relative positions in the scale of the evolutionary development of the genus: — *Amphisolenia inflata*, *A. laticincta*, *A. brevicauda*, *A schauinslandi*, *A. rectangulata*, and *A. astragalus*.

Amphisolenia inflata Murray and Whitting

Plate 6, fig. 2, 7. Figure 47, 49: 1

Amphisolenia inflata Murray & Whitting, 1899, p. 332, tab. 8, pl. 31, fig. 2a, b. Lemmermann, 1899a, p. 373; 1905a, p. 37. Schröder, 1900a, p. 20; 1906a, p. 324, 328. Cleve, 1903b, p. 339. Ostenfeld & Paulsen, 1904, p. 164, 173. Paulsen, 1908, p. 21, fig. 24.

Diagnosis: — Straight. Head twice as wide as long. Epitheca concave. Midbody very large, ovoidal, well set off from anterior process and antapical; subequal in length to antapical and somewhat longer than anterior part of body. Ratio between length and width of body, 4.2–4.3: 1. Antapical straight, not inflated posteriorly. Antapex with two lateral spinules. Wall profusely pitted, neck reticulate. Length, 143–233 μ.

Probably of world-wide distribution in tropical, subtropical, and warm-temperate regions of the sea.

Description: — The longitudinal axis of the body is almost straight. The head is subhorizontal or inclined anteriorly at an angle of about 10°; its axial length is 0.38–0.50 the length of the neck; and it is about twice as wide as long. The anterior face of the epitheca is distinctly concave. The transverse furrow is 0.4 as wide as the dorsoventral diameter of the head, somewhat concave, and without cross-ridges. The cingular lists are about twice as wide as the transverse furrow; the anterior flares anteriorly at an angle of 10°–20° and has, dorsally and ventrally only, a few branched ribs; the posterior is subhorizontal and lacks ribs.

The neck is short and thick, 0.10–0.11 the length of the body, and 2.5–3.5 times longer than wide. The sulcal lists continue beyond the flagellar pore to the midbody. They are reticulated anteriorly, and the left has, near the flagellar pore, a characteristic thickened area with a cross-rib in front of the pore.

The anterior process is 0.64–0.69 the length of the neck and about as long as wide.

The midbody is relatively very large, ovoidal, compressed laterally, and well set off from the anterior process and from the antapical. Its length is 3.5–3.6 and its width 2.1–2.2 the length of the neck. The ratio between the length and the greatest width of the body is 4.2–4.3: 1. In lateral view the midbody is about twice as wide as in dorsoventral view.

The antapical is unbranched, straight, 3.1–3.8 the length of the neck and 7–12 times longer than its average width. When viewed laterally, it tapers to a point posteriorly; when seen dorsoventrally, it tapers very little and terminates in two spreading, rather stout lateral spinules.

The thecal wall is characterized by a very distinct structural differentiation. On the antapical and on the midbody it has numerous closely placed, scattered, minute pits (pores?). On the anterior process the pits are larger and more widely spaced; on the neck they widen to a coarse reticulum, about three meshes wide on each valve.

The nucleus is large and oval. The chromatophores are numerous, of various sizes, and dark brown in color.

The proportions of two specimens, the type (Murray and Whitting, 1899, pl. 31, fig. 2a) and one taken by the Expedition, were measured.

Dimensions: — Our specimen: Length of body, 143 μ. Length of head, 8.0 μ. Length of neck, 16 μ. Length of anterior process, 11 μ. Length of midbody, 58 μ. Width of midbody, 33 μ. Length of antapical, 50 μ. Type specimen (Murray and Whitting, 1899, pl. 31, fig. 2a): Length of body, 233 μ. Length of head, 9.5 μ. Length of neck, 25 μ; apparently it is somewhat shorter because of

the fact that the thickened area of the left sulcal list has been drawn as if it belonged to the anterior process. Length of anterior process, 16 μ. Length of midbody, 88 μ. Width of midbody, 56 μ. Length of antapical, 94 μ.

Variations: — Judging by the two specimens thus far figured, the type specimen (Murray and Whitting, 1899, pl. 31, fig. 2a) and the specimen represented by our Plate 6, figure 7, this species appears to be rather constant. Most variable are the length of the body, and the relative width of the midbody and of the antapical.

Comparisons:—The three specimens referred to *Amphisolenia inflata* in this paper agree rather closely with the type of this species as figured by Murray and Whitting (1899). They differ from the type specimen mainly in the length of the body, and in the relative width of the midbody and of the antapical.

Amphisolenia inflata occupies a rather isolated position. We do not know which of the described species of Amphisolenia is its closest relative. It appears to be one of the most primitive, possibly the most primitive, species of this genus at present known. The following of its characters appear to be more or less primitive: — (*1*) the small size of the body; (*2*) the straight longitudinal axis of the body; (*3*) the exceptionally large, bilaterally compressed midbody; (*4*) the simple, unbranched antapical; (*5*) the well-developed structural differentiation of the thecal wall, fine areoles, and reticulation; (*6*) the reticulation of the sulcal lists; (*7*) the continuation of the sulcal lists beyond the flagellar pore. The question as to whether or not the concavity of the anterior face of the epitheca is primitive cannot be settled as yet. This is a peculiarity of this species and of *Triposolenia truncata* that has not been found in any other species of these two genera or in the primitive genera of this tribe. As to the relationship between *Amphisolenia inflata* and *Triposolenia truncata*, see the section on the subdivisions of this family.

Synonymy: — The species was established by Murray and Whitting (1899) under the name of *Amphisolenia inflata*. Paulsen (1908) reproduces the figure of the type specimen.

Occurrence: — The species is recorded at three of the 127 stations with a total of three specimens. There are 0, 0, 1, 1, 1, and 0 stations on the six lines of the Expedition. One of these three stations (4713) is in the Galapagos Eddy; the two others (4681, 4724) are in the South Equatorial Drift. One of the catches (4681) was from 800–0 fathoms, the two others from 300–0 fathoms.

The temperature range of these three stations at the surface was 68°–79°; the average was 73.3°. The frequency is less than 1%.

The species was first recorded by Murray and Whitting (1899) from the

Sargasso Sea, lat. 34°–39° N., long. 39°–32° W., the type locality. Later it was reported from lat. 59° N., long. 21° W. (the Gulf Stream) by Ostenfeld and Paulsen (1904); from lat. 15° N., long. 52° E. (the Arabian Sea) by Cleve (1903b); and from the Gulf of Aden and the Indian Ocean, between Ceylon and Singapore, by Schröder (1906a). All the samples in which the species was found were from surface waters.

The species occurs in waters of the following temperatures and salinities: — Murray and Whitting (1899): temperature, 66°–60°; Ostenfeld and Paulsen (1904): temperature, 49.3°; salinity, 35.30; Cleve (1903b): temperature, 74.3°; salinity, 36.02.

Ostenfeld and Paulsen (1904), Cleve (1903b), and Schröder (1906a) do not give any information as to the structure of their specimens.

The species is probably eupelagic and of world-wide distribution in tropical and subtropical waters and only occasionally is carried by currents to the colder regions of the sea.

Amphisolenia laticincta Kofoid

Plate 6, fig. 6, 8, 9. Figure 49: 2, 50: 10

Amphisolenia laticincta Kofoid, 1907a, p. 198, pl. 13, fig. 80.

Diagnosis: — Straight. Head but slightly wider than neck, almost twice as long as wide, hourglass-shaped. Epitheca boldly convex. Midbody fusiform, gradually merging into anterior process but set off from antapical. Distance from flagellar pore to antapical not quite half as long as body and somewhat longer than antapical. Ratio between length and width of body, 12: 1. Antapical straight, not inflated posteriorly. Antapex round with one short spinule (in typical specimens probably with one spinule on each valve). Length, 117–136 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is almost straight. The head is but slightly wider than the neck, of which it forms a continuation in a nearly straight line; its axial length is almost twice its width and subequal to or rather slightly shorter than the length of the neck. The epitheca is oblique and much more convex dorsally than ventrally. The transverse furrow is very broad, somewhat wider than the dorsoventral diameter of the head; it is rather strikingly concave, which gives to the head the shape of an hourglass, and without cross-ridges. The anterior cingular list is subhorizontal or it flares anteriorly at an angle of 10°; its width is 0.5 the width of the transverse furrow and subequal to the width of the neck; it has, on each valve, two to three simple ribs. The poste-

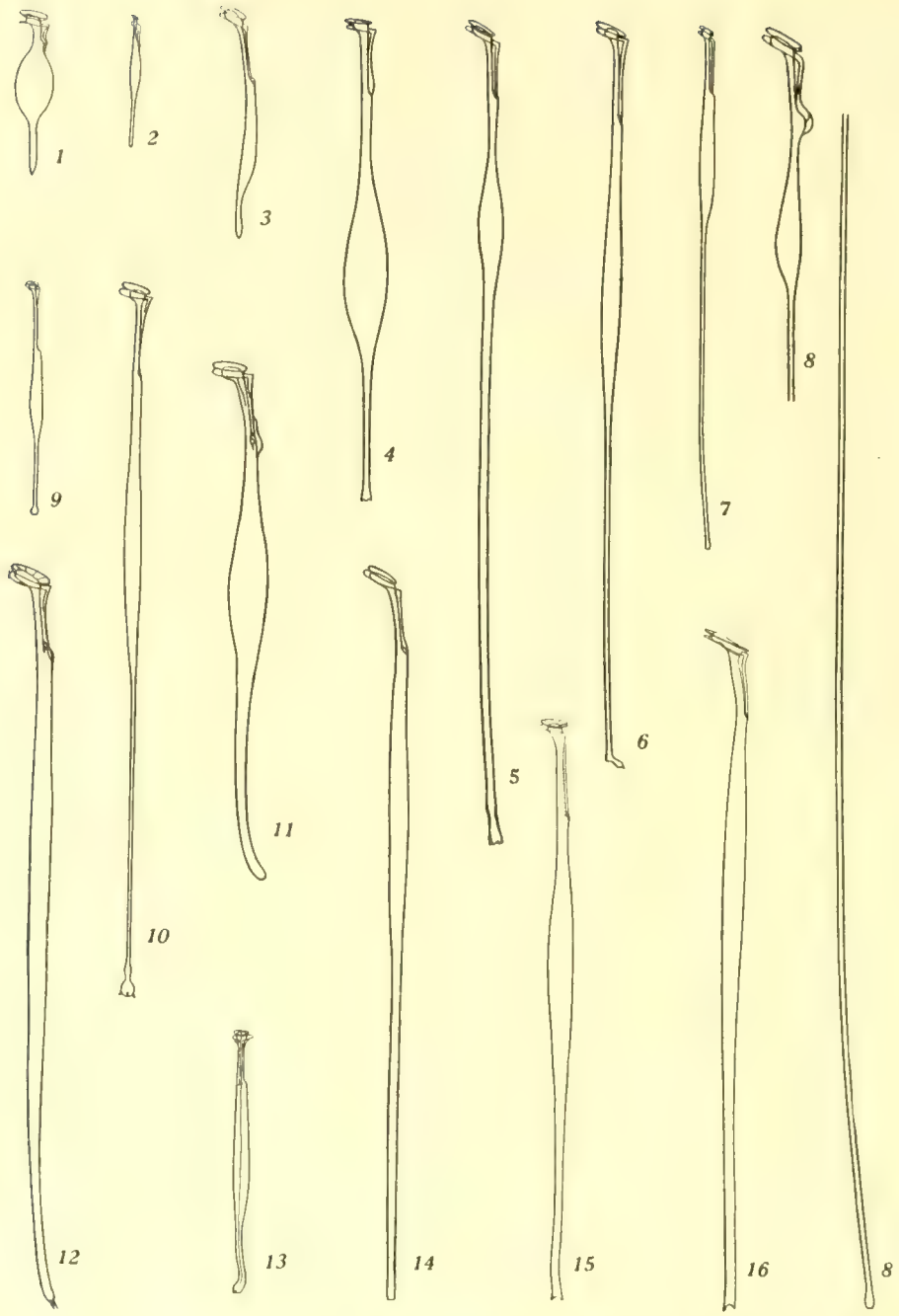

FIGURE 49.— 1, *Amphisolenia inflata* Murray and Whitting. Station 4681 (300–0 fathoms). 2, *A. laticincta* Kofoid. Station 4740 (300–0 fathoms). 3, *A. brevicauda* Kofoid. Station 4740 (300–0 fathoms). 4, *A. schauinslandi* Lemmermann. Station 4736 (300–0 fathoms). 5, *A. rectangulata* Kofoid. Station 4740 (300–0 fathoms). 6, *A. astragalus* Kofoid and Michener. Station 4713 (300–0 fathoms). 7, *A. elongata*, sp. nov. Station 4681 (800–0 fathoms). 8, *A. extensa* Kofoid, posterior portion of antapical is a direct continuation of anterior. Station 4699 (300–0 fathoms). 9, *A. globifera* Stein. Station 4742 (300–0 fathoms). 10, *A. quadrispina* Kofoid. Station 4711 (300–0 fathoms). 11, *A. curvata* Kofoid. Station 4605 (300–0 fathoms). 12, *A. bispinosa* Kofoid. Station 4605 (300–0 fathoms). 13, *A. clavipes* Kofoid. Station 4736 (300–0 fathoms). 14, *A. truncata* Kofoid and Michener. Station 4733, surface. 15, *A. schröderi* Kofoid. Station 4737 (300–0 fathoms). 16, *A. complanata*, sp. nov. Station 4739 (300–0 fathoms). Figure 2, 3, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16 from type specimens; right lateral view. × 150.

rior cingular list flares anteriorly at an angle of 20°–30°, is somewhat wider than the anterior, and has no ribs.

The neck is rather short and thick, 0.09 the length of the body and 4.5 times longer than wide. The sulcal lists extend to the flagellar pore. An accessory list, arising from the originally free edge of the left sulcal list and about as wide as the neck, extends along the whole length of the neck and continues for a short distance behind the pore. The lists are without ribs; the fission rib has not been seen.

The midbody is fusiform and merges gradually into the anterior process but is fairly well set off from the antapical. The distance between the flagellar pore and the antapical is about 16 times longer than the neck. The midbody is widest somewhat in front of the middle of the body, and its greatest width is subequal to the length of the neck. The ratio between the length and the greatest width of the body is 12: 1.

The antapical is unbranched, straight, 4.5 times longer than the neck, 20 times longer than wide, as wide as the neck, of uniform width throughout its whole length, not inflated posteriorly. The antapex is rounded and has a single, minute spinule (in typical specimens probably one on each valve).

The thecal wall is apparently without structure except for a few fine pores along the base of each of the sulcal lists.

The nucleus is elongated, ellipsoidal. The chromatophores are numerous, small, spheroidal, and of a yellowish-green color.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 117–136 μ (type, 117 μ; not 112 μ as stated in the original description). Length of head, 9 μ. Length of neck, 9 μ. Length of anterior process and midbody, 56 μ. Width of midbody, 9 μ. Length of antapical, 40 μ.

Comparisons: — The description given above is based on the type material.

The small size, the straight longitudinal axis of the body, the fairly well-developed midbody set off from the antapical, and the simple, unbranched antapical seem to indicate that this species is fairly low in the scale of the evolutionary development of the genus. The narrowness of the head and the wideness of the transverse furrow, on the other hand, are secondary features, as is shown by the relative wideness of the head and narrowness of the transverse furrow in the presumably primitive *Amphisolenia inflata* as well as in most of the other species of this genus.

This species occupies an isolated position in the genus Amphisolenia. It may be noted in this connection that it resembles *A. curvata* in having on the left

sulcal list an accessory list continuing for a short distance behind the flagellar pore. In other respects, however, these two species are very different (see the section on the reproduction of this genus).

Occurrence: — The species is recorded at two of the 127 stations with a total of two specimens. One of these two stations (4701) is on the fourth, the other (4740) on the fifth line of the Expedition, and both are in the South Equatorial Drift. The catches are from 300–0 fathoms.

The temperature of these two stations at the surface was 72° and 81°.

The frequency is less than 1%.

The species was first reported by Kofoid (1907a) from Station 4740 of the Expedition, which thus is the type locality.

Amphisolenia brevicauda Kofoid

Plate 6, fig. 1, 4. Figure 49: 3, 50: 6

Amphisolenia brevicauda Kofoid, 1907a, p. 197, pl. 13, fig. 79.

Diagnosis: — With moderate sigmoid curvature. Head 2.5–3.0 times wider than long. Epitheca flat. Midbody elongated; gradually merging into anterior process but well set off from antapical; slightly widened posteriorly; its dorsal margin slightly concave, flat, or, at any rate, less convex than its ventral margin. Distance from flagellar pore to antapical about half as long as body. Ratio between length and width of body, 16: 1. Antapical straight, somewhat shorter than neck, not inflated posteriorly. Antapex acute and without spinules. Length 202 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body has a moderate sigmoid curvature, with the neck somewhat deflected dorsally and the antapical ventrally.

The head is inclined anteriorly at an angle of 40°; it is 0.16–0.17 the length of the neck and 2.5–3.0 times wider than long. The anterior face of the epitheca is flattened, very slightly convex. The transverse furrow is 0.20 as wide as the dorsoventral diameter of the head, somewhat convex and without cross-ridges. The cingular lists are 1.3 as wide as the transverse furrow; the anterior flares anteriorly at an angle of 20°; the posterior is subhorizontal; each list has, on each valve, five to six fine, simple ribs.

The neck is rather long and narrow; it is 0.25 the length of the body and 10–12 times longer than wide. The sulcal lists end near the flagellar pore and have no ribs.

The anterior process and the midbody are perfectly merged, elongated,

irregularly fusiform, and about half as long as the body or somewhat more than twice as long as the neck. The midbody is slightly widened posteriorly; it is widest at a distance from the apex equaling about two thirds the length of the body or at a distance from the flagellar pore 1.5 the length of the neck. Its great-

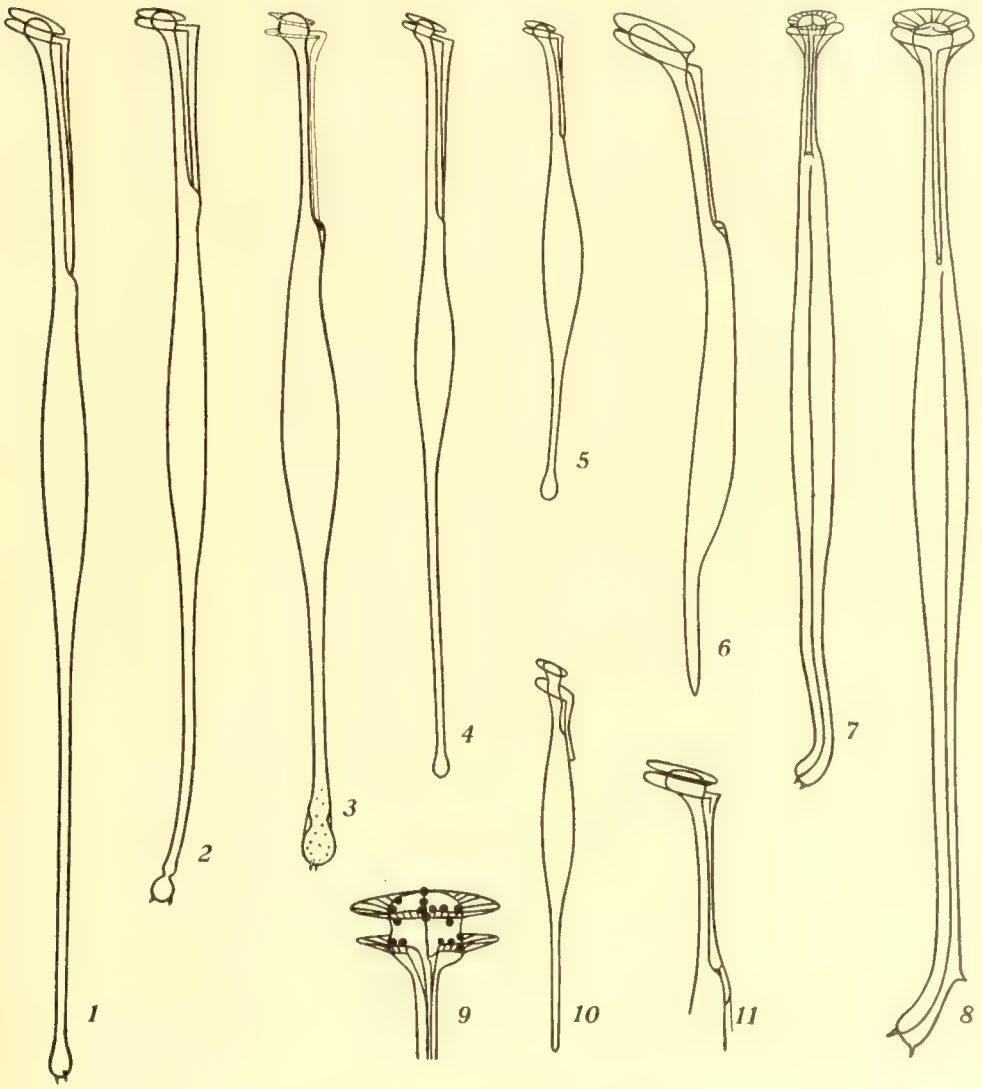

FIGURE 50.— 1–5, *Amphisolenia globifera* Stein, right lateral view showing the striking variability of the size and shape of this species. × 430. 1, 2, from Station 4742 (300–0 fathoms); 3, from Station 4613 (300–0 fathoms); 4, from Station 4721 (300–0 fathoms); 5, from Station 4711 (300–0 fathoms). 6, *A. brevicauda* Kofoid, right lateral view of type specimen. × 430. Station 4740 (300–0 fathoms). 7, *A. clavipes* Kofoid, ventral view of type specimen. × 430. Station 4736 (300–0 fathoms). 8, *A. lemmermanni* Kofoid, ventral view. × 430. Station 4734 (300–0 fathoms). 9, *A. quadrispina* Kofoid, ventral view of anterior portion of body showing phaeosomes. × about 650. Station 4711 (300–0 fathoms). 10, *A. laticincta* Kofoid, right lateral view of type specimen. × 430. Station 4740 (300–0 fathoms). 11, *A. elongata*, sp. nov., right lateral view of anterior portion of body. × 430. Station 4737 (300–0 fathoms).

est width is 0.27 the length of the neck. The ratio between the length and the greatest width of the body is about 16: 1. The dorsal margin of the midbody is slightly concave, almost straight or at least less convex than the ventral margin.

The antapical is well set off from the midbody, unbranched, straight, and exceptionally short, about 0.19 the length of the body or somewhat shorter than the neck; about ten times longer than wide or about as wide as the neck. It tapers posteriorly to a simple, acute antapex, without spinules or other differentiations.

The thecal wall is apparently structureless.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 202 μ. Length of head, 8 μ. Length of neck, 45 μ. Length of anterior process and midbody, 104 μ. Width of midbody, 12 μ. Length of antapical, 37 μ.

Comparisons: — The description given above is based on the type material.

The small size of the body and the simple, unbranched antapical, well set off from the midbody appear to be primitive features. The peculiar asymmetry of the midbody is unique for this genus. The relative shortness of the antapical and the simple, pointed antapex also contribute to the exceptional appearance of this species.

The species occupies a rather isolated position. It may possibly be a representative of an evolutionary branch which split off at a fairly early stage in the phylogenetic differentiation of the genus and in which the tendency to posterior elongation has been inhibited.

Occurrence: — The species is recorded at two of the 127 stations with a total of two specimens. One (4736) of these two stations is on the fifth, the other (4740) on the sixth line of the Expedition. Both are in the South Equatorial Drift. The samples are from 300–0 fathoms.

The temperature of these two stations at the surface was 81°.

The frequency is less than 1%.

The species was first recorded by Kofoid (1907a) from Station 4740 of the Expedition which thus is the type locality.

Amphisolenia schauinslandi Lemmermann

Plate 7, fig. 1–8. Figure 49: 4, 51

Amphisolenia schauinslandii Lemmermann, 1899a, p. 317, 350, 373, pl. 1, fig. 18, 19; 1901a, p. 376; 1904, p. 609, 611, 643. Schröder, 1900a, p. 20; 1906a, p. 328. Ostenfeld & Schmidt, 1901, p. 162.

Diagnosis: — Straight. Head capitate, 1.3–1.5 times wider than long. Epitheca convex or somewhat flattened. Midbody fusiform; fairly well set off

from or gradually merging into anterior process and antapical; its length 2.8–3.5 the length of neck, of moderate width or rather slender. Ratio between length and width of body, 10–15: 1. Anterior process exceptionally long, 1.3–1.6 the length of neck. Antapical straight, 2.3–3.0 the length of neck; its posterior end sometimes slightly inflated, truncate, rectangular. Antapex with a short spinule at each of the four corners. Length, 391–434 μ.

Tropical and subtropical regions of Pacific, Indian Ocean, Gulf of Aden.

Description: — The longitudinal axis of the body is straight. The head is subhorizontal or inclined anteriorly at an angle of 25°; its axial length is 0.19 the length of the neck; capitate, 1.3–1.5 times wider than long. The anterior face of the epitheca is convex or somewhat flattened. The transverse furrow is 0.3–0.4 as wide as the dorsoventral diameter of the head, somewhat convex, and without cross-ridges. The cingular lists are about as wide as or somewhat wider than the transverse furrow; the anterior flares anteriorly at an angle of 10°–20°; the posterior flares somewhat less; the anterior has, on each valve, seven or eight simple, equidistant ribs; the posterior has the same number or somewhat less.

The neck is rather long and narrow; it is 0.11–0.13 the length of the body and eight to nine times longer than wide. The sulcal lists end at the flagellar pore; they lack ribs except for the fission rib of the left list.

The midbody is fusiform and either fairly well set off from or gradually merging into the anterior process and the antapical. When the anterior process is more or less distinctly set off from the midbody, it is exceptionally long, 1.3–1.6 the length of the neck; its exceptional length gives to this species its peculiar and characteristic habitus. The distance between the flagellar pore and the anterior end of the antapical is four to five times the length of the neck. The midbody is of moderate length, 2.8–3.5 the length of the neck, and of moderate width or rather slender, widest near or somewhat behind the middle of the body; its greatest width is 0.60–0.75 the length of the neck. The ratio between the length and the greatest width of the body is 10–15: 1.

The antapical is unbranched and straight. When set off from the midbody, it is 2.3–3.0 the length of the neck or 0.28–0.35 the length of the body, 20–25 times longer than wide and about as wide as the neck. Its distal end is truncate, rectangular, of about the same width as its middle portion or sometimes slightly inflated. The antapex has a short, strong spinule at each of its four corners.

The thecal wall is faintly porulate. On the neck there are two rows of pores on each valve, one along the base of the sulcal list, and one along the dorsal suture.

The nucleus is rather large. The chromatophores are fairly numerous, rod-like and yellowish brown.

The proportions of one specimen from the material of the Expedition and of the type specimen were measured.

Dimensions: — Length of body, 391–434 μ (average, 416 μ). Length of head, 10 μ. Length of neck, 50 μ. Length of anterior process, midbody, and antapical, 365 μ. Approximate length of anterior process, 85 μ. Approximate length of midbody, 152 μ. Approximate length of antapical, 128 μ. Width of midbody, 38 μ. The length of the type specimen is unknown. According to a statement in the original description, it would be 544 μ; according to the size of the original drawing (Lemmermann, 1899a, pl. 1, fig. 19), the magnification of which is 305 diameters, it would be 232 μ.

Variations: — The species appears to be rather constant. The size of the body and the width of the midbody are the most variable characters. The posterior end of the antapical is sometimes slightly inflated, sometimes not.

Comparisons: — The specimens referred to *Amphisolenia schauinslandi* in this paper agree closely with the type of this species as figured by Lemmermann (1899a, pl. 1, fig. 19). In some of them the midbody is somewhat wider relatively than in the type specimen, and the posterior end of the antapical is somewhat inflated.

The straight longitudinal axis of the body, the fairly well-developed midbody, which in most specimens is rather distinctly set off from the antapical, and the simple, unbranched antapical appear to be primitive features of this species. The anterior process, which, secondarily, is longer than in any other known member of this genus, gives to the species a rather unique habitus.

Amphisolenia schauinslandi occupies a rather isolated position. The shape and the structure of the posterior end of its antapical are suggestive of *A. rectangulata.*

Occurrence: — The species is recorded at fourteen of the 127 stations. There are 3, 0, 0, 2, 8, and 1 stations on the six lines of the Expedition. Of these fourteen stations, three (4587, 4588, 4590) are in the Mexican Current; one (4699) is in the Easter Island Eddy; and ten (4701, 4722, 4725, 4732, 4734, 4735, 4736, 4737, 4739, 4740) are in the South Equatorial Drift. At three stations (4588, 4725, 4737) the species was found in surface catches only. At Station 4732 it is recorded from 800–0 fathoms and 300–0 fathoms, at Station 4737 from 100–0 fathoms and 300–0 fathoms. All the other records refer to catches from 300–0 fathoms only.

The temperature range of these fourteen stations at the surface was 72°–83°;

the average was 79.2°. At the three stations in the surface samples of which this species was found, the surface temperature ranged from 77° to 82°; the average was 80.0°.

The frequency does not exceed 1%, which occurs at one station only (4590).

The species was first recorded by Lemmermann (1899a, 1904) from the tropical region of the Pacific, between Laysan Island and the Hawaiian Islands, the type locality. Later it was recorded by Ostenfeld and Schmidt (1901) from the Gulf of Aden, lat. 12° 35′ N., long. 55° 55′ E.; and by Schröder (1906a) from

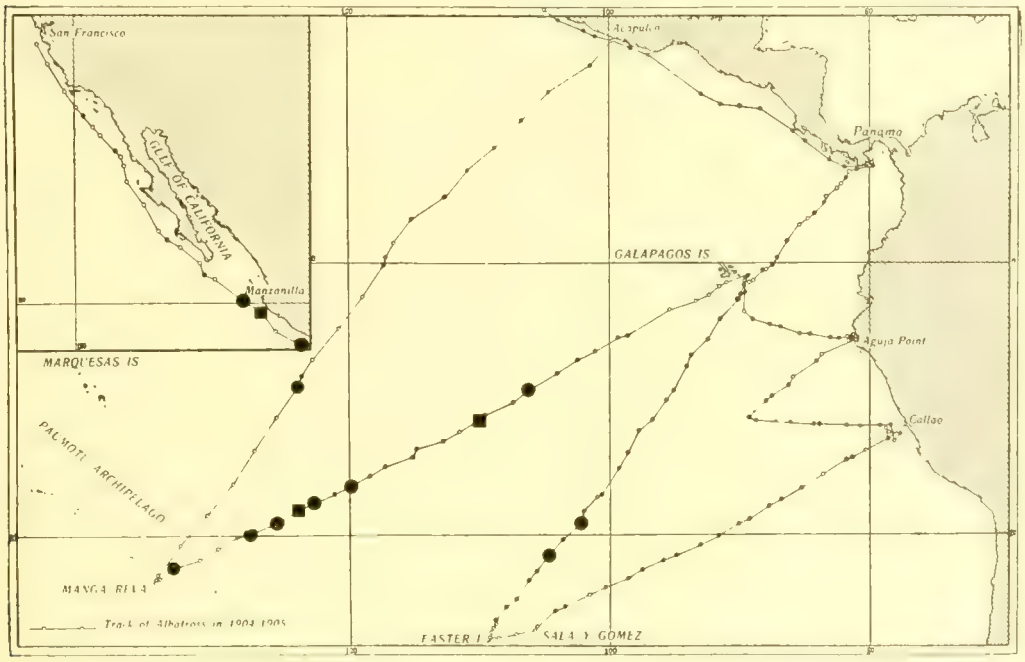

FIGURE 51.— Occurrence of *Amphisolenia schauinslandi* Lemmermann. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

the Indian Ocean, south of Ceylon. The sample in which Ostenfeld and Schmidt (1901) found this species was from a depth of 20 feet; Lemmermann's (1899a) and Schröder's (1906a) samples probably were taken near the surface.

Ostenfeld and Schmidt (1901) found the species in water of a temperature of 82.4°.

Ostenfeld and Schmidt (1901) and Schröder (1906a) do not give any information as to the structure of their specimens.

This is probably a eupelagic species of world-wide distribution in tropical and subtropical seas. The most striking features of its occurrence in the Eastern Pacific, according to our records, are its predominance in the western portion of

the South Equatorial Drift and in the Mexican Current, and its absence from the California Current, the Panamic Area, and the Peruvian Current. The average temperature of its habitat is exceptionally high (79.2°).

Amphisolenia rectangulata Kofoid

Plate 8, fig. 3, 5, 6, 7, 9. Figure 49: 5

Amphisolenia rectangulata Kofoid, 1907a, p. 200, pl. 14, fig. 83.

Diagnosis: — With slight sigmoid curvature. Head 2.0–3.0 times wider than long. Epitheca flat. Midbody fusiform, gradually merging into anterior process and antapical. Distance from flagellar pore to antapical, 4.6 the length of neck. Ratio between length and width of body, 34: 1. Antapical slightly and evenly concave ventrally, ten times longer than neck; its posterior end sometimes slightly widened, truncate, rectangular. Antapex with a short spinule on each of the four corners. Length, 531–734 μ.

Tropical and subtropical regions of Eastern Pacific.

Description: — The longitudinal axis of the body has a slight sigmoid curvature, with the neck slightly deflected dorsally, and the antapical slightly concave ventrally.

The head is inclined anteriorly at an angle of 20°–30°; its axial length is 0.15–0.18 the length of the neck, and it is 2.0–3.0 times wider than long. The anterior face of the epitheca is flat. The transverse furrow is 0.20 as wide as the dorsoventral diameter of the head, somewhat convex, and without cross-ridges. The cingular lists are about twice as wide as the transverse furrow; the anterior flares anteriorly at an angle of 20° and has, on each valve, seven or eight equidistant, simple ribs; the posterior is subhorizontal and has, on each valve, five or six similar ribs.

The neck is of moderate length and narrow; it is 0.06 the length of the body and ten times longer than wide. The sulcal lists end at the flagellar pore and lack ribs.

The midbody is fusiform and merges gradually into the anterior process and into the antapical. The distance between the flagellar pore and the anterior end of the antapical is 4.6 the length of the neck. The midbody is rather slender, widest at a distance from the apex equaling about 0.25 the length of the body or at a distance from the flagellar pore 2.5 times longer than the neck; its greatest width is subequal to 0.5 the length of the neck. The ratio between the length and the greatest width of the body is about 34: 1.

The antapical is unbranched, slightly and evenly concave ventrally; long,

ten times longer than the neck and twice the total length of the anterior process and the midbody; 55–60 times longer than wide and somewhat wider than the neck. The posterior end of the antapical is sometimes slightly widened, truncate, rectangular; its ventral face is somewhat narrower than its lateral face (Plate 8, fig. 5, 6); on each of the four corners there is a short, acute antapical spinule.

The thecal wall is apparently without structure. The posterior end of the antapical is porulate on its lateral sides, and has a row of pores along either side of the sagittal-suture line.

The nucleus is long and narrow. The chromatophores are spheroidal and numerous.

The proportions of one specimen, the type, were carefully measured. In the case of the head and the neck, one more specimen was measured.

Dimensions: — Length of body, 531–734 μ (type, 734 μ). Length of head, 7–9 μ. Length of neck, 47 μ. Length of anterior process and midbody, 217 μ. Width of midbody, 23 μ. Length of antapical, 453 μ.

Variations: — Very little is known about the variability of this species. The size of the body, the width of the head, and the degree of inflation of the posterior end of the antapical vary in our material.

Comparisons: — The description given above is based on the type material.

The simple, unbranched type of the antapical appears to be a primitive feature of this species. On the other hand, the slightly sigmoid curvature of the longitudinal axis of the body, the relatively great width of the head, the slenderness of the midbody, the merging of the midbody into the antapical, and the great elongation of the antapical probably are advances in differentiation.

Amphisolenia rectangulata resembles *A. schauinslandi* in the symmetrical and subrectangular posterior portion of its antapical and in its truncate antapex with four symmetrically arranged spinules, one on each of the four corners, and two on each valve. However, in other respects the last species differs very strikingly from the first, *e.g.*, in the narrowness of the head, in the extreme elongation of the anterior process, and in the moderate length of the antapical.

Another species with symmetrical posterior portion of the antapical and with four symmetrically arranged spinules, two on each valve, is *A. quadrispina*. This species, which resembles *A. rectangulata* also in the slenderness of its midbody, differs very conspicuously in the wide, knob-like termination of its antapical and in the neck-like constriction and slight inflation in front of the terminal knob. The four symmetrically arranged spinules on the antapex and the slenderness of the midbody are probably not the results of common inheritance but of

independent differentiation. *A. quadrispina* probably originated from a form very similar to *A. globifera*, *i.e.*, a form of moderate size, fairly wide midbody, moderately long antapical, and with but two antapical spinules. We are without clue as to the ancestral relationships of *A. rectangulata*.

Great elongation of the antapical and symmetrical development of the posterior portion of this part of the body are characteristics of *A. rectangulata* that are found also in *A. extensa*. In the shape and structure of the posterior portion of the antapical these two species are quite different.

Occurrence: — *Amphisolenia rectangulata* is recorded at five of the 127 stations. There are 2, 0, 0, 0, 2, and 1 stations on the six lines of the Expedition. Of these five stations, one (4587) is in the Mexican Current; one (4617) is in the Panamic Area; three (4734, 4739, 4740) are in the South Equatorial Drift. All the catches are from 300–0 fathoms.

The temperature range of these five stations at the surface was 78°–81°; the average was 80.2°.

The frequency is less than 1%. The species was first reported by Kofoid (1907a) from Station 4740 of the Expedition which thus is the type locality.

This is probably a eupelagic species of tropical and subtropical nature. The most outstanding peculiarities in its distribution in the Eastern Pacific, according to our data, are its occurrence in the Mexican Current, Panamic Area, and South Equatorial Drift, and its absence from the Peruvian Current. The average temperature of its habitat is exceptionally high (80.2°).

Amphisolenia astragalus Kofoid and Michener

Plate 10, fig. 1, 6, 8, 10. Figure 49: 6

Amphisolenia astragalus Kofoid & Michener, 1911, p. 293.

Diagnosis: — With very slight sigmoid curvature. Head 1.2 times wider than long. Epitheca gently convex. Midbody fusiform, gradually merging into anterior process but rather well set off from antapical. Distance from flagellar pore to antapical 4.0 the length of neck. Ratio between length and width of body, 45: 1. Antapical 4.6 times longer than neck, almost straight except posteriorly, where it is bent ventrally at an angle of 50°; at point of bending there is a rounded dorsal heel which gives to posterior part a foot-like shape. Antapex rounded, with a distal spinule and a rounded lateral projection. Length, 658 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is very slightly sigmoid,

the neck being slightly deflected dorsally, and the antapical having a very slight ventral concavity. The tip of the antapical has a very abrupt ventral bend.

The head is inclined anteriorly at an angle of 15°–20°; its axial length is 0.15 the length of the neck; and it is 1.2–1.3 times wider than long. The anterior face of the epitheca is gently convex. The transverse furrow is 0.33 as wide as the dorsoventral diameter of the head, very slightly concave, and has, on each valve, five or six almost equidistant cross-ridges, some of which may be somewhat irregular. The anterior cingular list is about twice as wide as the transverse furrow, flares anteriorly at an angle of about 15° and has, on each valve, ten simple, equidistant ribs. The posterior cingular list is somewhat narrower, subhorizontal, and has the same or a somewhat smaller number of similar ribs.

The neck is of moderate length, 0.10 the length of the body, and rather narrow, about 16 times longer than wide. On each valve, somewhat dorsally to the middle, it has a low, narrow longitudinal ridge, which in the type specimen extends from the girdle along the anterior quarter of the length of the neck. The sulcal lists end at the cytopharyngeal pore; in the type specimen the right list has a marginal rib along the anterior quarter of its margin.

The midbody is fusiform and merges gradually into the anterior process but is fairly well set off from the antapical. The distance between the flagellar pore and the antapical is 4.0 the length of the neck. The midbody is very slender, widest at a distance from the apex equaling two fifths of the length of the body, or at a distance from the flagellar pore 2.5 times longer than the neck; its greatest width is 0.24 the length of the neck. The ratio between the length and the greatest width of the body is 45: 1.

The antapical is unbranched, with a very gentle ventral concavity except near the posterior end where it is bent abruptly ventrally at an angle of 50°. It is 4.6 times longer than the neck and 1.2 the total length of the anterior process and the midbody. It is of almost uniform width throughout its whole length except near the posterior end where it is slightly widened; its average width is about the same as that of the neck, and it is about 70 times longer than wide. At the point of the abrupt bending, near the antapex, there is a well-developed, rounded, heel-like dorsal protuberance, which gives to the distal part of the antapical, in lateral view, a foot-like appearance. Seen laterally, the foot-like part is somewhat less than three times longer than wide. The antapex is rounded and has a rather strong distal spinule and a rounded lateral projection.

The thecal wall is almost without structure. On the posterior end of the antapical there is a row of pores on either side of the ventral suture line and some

scattered pores on the foot-like part of the antapical. The porulation of the neck is unknown (see also the description of the neck).

The nucleus is of moderate size and elongated. The chromatophores are rather few, round or ellipsoidal; some of them are yellowish.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 658 μ. Length of head, 9.5 μ. Length of neck, 66 μ. Length of anterior process and midbody, 268 μ. Width of midbody, 16.5 μ. Length of antapical, 314 μ.

Comparisons: — The description given above is based on the type material.

This highly differentiated species has an uncertain position within the genus Amphisolenia. The abrupt ventral bending of the posterior foot-like portion of its antapical is unique as far as the known species of this genus are concerned. It should be mentioned, however, that our interpretation of the direction of this bending is somewhat uncertain since the course of the posterior portion of the sagittal suture has not been followed with certainty. Our decision in this case is based on the position of what appear to be the pores of this suture. The ventral bending may be apparent; it may be a bending to the right combined with ventral torsion. If this be the case, then *A. astragalus* in this respect agrees with *A. bidentata*. However, even so, the single distal spinule and the rounded lateral protuberance on the posterior portion of the antapical give to *A. astragalus* an appearance quite different from that of *A. bidentata*. Furthermore, *A. astragalus* differs from all the species of the PALMATA group in not having any "heel-spinule" on the antapical. In this respect it is somewhat closer to the SCHRÖDERI group, from which the PALMATA group presumably originated. It should be remembered however, that the species of the SCHRÖDERI group have no indication of an antapical heel, while in *A. astragalus* a large, *rounded* heel is developed.

Occurrence: — *Amphisolenia astragalus* is recorded at only one of the 127 stations. This station (4713) is on the fourth line of the Expedition and in the Galapagos Eddy. The depth is 300–0 fathoms, the surface temperature 73°, and the frequency less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) at Station 4713 of the Expedition which thus is the type locality.

2. EXTENSA GROUP. Both the species belonging to this group, viz., *Amphisolenia extensa* and *A. elongata*, have been found in the material of the Expedition.

Amphisolenia extensa Kofoid

Plate 6, fig. 3, 5. Figure 49: 8, 52

Amphisolenia extensa Kofoid, 1907a, p. 198, pl. 13, fig. 78. Doflein, 1909, p. 464, fig. 403c; 1911, p. 531, fig. 462e; 1916, p. 437, fig. 374e. Jörgensen, 1923, p. 41, fig. 60.

Diagnosis: — With more or less pronounced sigmoid curvature. Head 1.4–2.5 times wider than long. Epitheca gently convex. Midbody fusiform, gradually merging into anterior process and antapical, or fairly well set off from antapical. Distance from flagellar pore to antapical 3.5–5.0 the length of neck. Ratio between length and width of body, 55–65: 1. Antapical concave ventrally, 22–33 times longer than neck; its posterior end slightly club-shaped, subtruncate. Antapex mostly without spinules or with one to four exceedingly small ones. Length, 1292–1520 μ.

Tropical and subtropical regions of Eastern Pacific; Mediterranean.

Description: — The longitudinal axis of the body has a more or less pronounced sigmoid curvature, with the neck slightly deflected dorsally, and the antapical more or less concave ventrally. In the specimens examined by us the ventral curvature of the antapical is slight or moderate (Figure 49: 8); in the specimen figured by Jörgensen (1923, fig. 60) it is very pronounced.

The head is inclined anteriorly at an angle of 40°; its axial length is 0.15–0.16 the length of the neck; and it is 1.4–2.5 (in our specimens, 2.0–2.5) times wider than long. The anterior face of the epitheca is gently convex. The transverse furrow is 0.20 as wide as the dorsoventral diameter of the head, flat; it has, on each valve, nine equidistant cross-ridges. The anterior cingular list is subhorizontal or flares anteriorly at an angle of 10°–15°; it is 1.5–3.0 as wide as the transverse furrow and has, on each valve, 10–11 equidistant, simple ribs. The posterior cingular list is subhorizontal, about as wide as or somewhat narrower than the anterior list and has about the same number of equidistant, simple ribs as the latter.

The neck is of moderate length and narrow; it is 0.02–0.04 the length of the body and 11–17 (in our specimens 16–17) times longer than wide. The sulcal lists extend to the flagellar pore and have anteriorly two to three longitudinal, irregular, and sometimes anastomosing ribs.

The midbody is fusiform and either merges gradually into the anterior process and into the antapical or is fairly well set off from the antapical. The distance between the flagellar pore and the anterior end of the antapical is 3.5–5.0 the length of the neck. The midbody is more or less slender, widest at a dis-

tance from the apex equaling 0.08–0.15 the length of the body or at a distance from the flagellar pore 2.0–3.0 times longer than the neck; its greatest width is subequal to or slightly less than 0.5 the length of the neck. The ratio between the length and the greatest width of the body is 55–65: 1.

The antapical is unbranched, evenly and either slightly or more or less strikingly (Jörgensen, 1923, fig. 60) concave ventrally. It is exceptionally long and narrow, 22–33 times longer than the neck and four to seven times longer than the total length of the anterior process and the midbody; it is as wide as the neck and of uniform width throughout its whole length except near the posterior end where it is slightly club-shaped. The antapex is subtruncate and in most cases without spinules, sometimes with one to four exceedingly small ones.

The thecal wall is apparently without structure; the posterior part of the antapical is porulate.

The nucleus is large, ovoidal or elongated. The chromatophores are numerous and spheroidal. In the midbody colorless plastids and some oil drops also are to be found.

The proportions of three of our specimens and of the specimen figured by Jörgensen (1923, fig. 60) were measured.

Dimensions: — Our specimens: Length of body, 1325–1520 μ (average, 1426 μ; type, 1400 μ). Length of head, 9 μ. Length of neck, 40–58 μ (average, 47 μ; type, 58 μ). Length of anterior process and midbody, 171–205 μ (average, 186 μ; type, 171 μ). Width of midbody, 18–23 μ (average, 21 μ; type, 23 μ). Length of antapical, 1070–1287 μ (average, 1172 μ; type, 1160 μ). Jörgensen's (1923) specimen: Length of body, 1292 μ. Width of midbody, 17 μ.

Variations: — The species appears to be fairly constant. The following characters are the most variable: — the size of the body, the curvature of the longitudinal axis of the body, the dorsoventral width of the head, and the relative length and width of the midbody.

Comparisons: — The description given above is based on the type material.

The specimen figured by Jörgensen (1923, fig. 60) under the name of *Amphisolenia extensa* differs from our specimens of this species in the following respects: — the body is slightly shorter; the antapical has a more pronounced ventral concavity; the dorsoventral width of the head is only 1.4 the axial length of the head; and the neck is slightly wider. In spite of these differences it seems rather probable that Jörgensen's assignment of this specimen is correct.

The simple, unbranched type of the antapical appears to be a primitive feature of this species. On the other hand, the more or less pronounced sigmoid

curvature of the longitudinal axis of the body, the slenderness of the midbody, the tendency of the midbody to merge into the antapical, and the excessive elongation of the antapical probably are secondary differentiations. No other known species of this genus has such a long and attenuated antapical.

Amphisolenia extensa is probably very closely related to *A. elongata* as is shown by the almost identical shape and structure of the posterior portions of the antapicals of these two species. The two forms most probably are specifically distinct, but, on the other hand, the possibility that they are but giant and dwarf variants of the same species should not be considered as excluded. The basis of separation of the two species lies not only in the much smaller size of *A. elongata* (438–464 μ) as compared with *A. extensa* (1292–1520 μ) but also in the proportions of the different parts. The head in *A. elongata* is only 1.5 times and in the Pacific specimens of *A. extensa* 2.0–2.5 times wider than long. In *A. elongata* the greatest width of the midbody is 0.30–0.40 the length of the neck, and the ratio between the length and the greatest width of the body is 30–35: 1. In *A. extensa* the corresponding values are 0.50 and 55–65: 1. The antapical is very short in *A. elongata* (six times longer than the neck and about twice the total length of the anterior process and the midbody) as compared with *A. extensa* (22–23 times longer than the neck and four to seven times longer than the total length of the anterior process and the midbody).

It should be noted that the specimen of *Amphisolenia extensa* figured by Jörgensen (1923, fig. 60) is in some respects intermediate between our specimens of this species and *A. elongata*, *e.g.*, in the shape of the head and of the midbody. The head of this specimen is only 1.4 times wider than long, in other words, even slightly narrower than the head in *A. elongata*.

Synonymy: — The species was established by Kofoid (1907a) under the name of *Amphisolenia extensa*. Reproductions of Kofoid's (1907a) figure of the type specimen are given by Doflein (1909, 1911, 1916).

Occurrence: — *Amphisolenia extensa* is recorded at thirty-three of the 127 stations. There are 7, 5, 3, 7, 9, and 2 stations on the six lines of the Expedition. Of these thirty-three stations, two (4580, 4583) are in the California Current; four (4587, 4594, 4598, 4605) are in the Mexican Current; three (4613, 4634, 4638) are in the Panamic Area; three (4650, 4667, 4668) are in the Peruvian Current; three (4691, 4697, 4699) are in the Easter Island Eddy; one (4713) is in the Galapagos Eddy; sixteen (4679, 4683, 4701, 4707, 4709, 4711, 4719, 4721, 4722, 4724, 4728, 4732, 4734, 4736, 4739, 4740) are in the South Equatorial Drift; one (4742) is in the South Equatorial Current. At four stations (4701, 4721, 4728,

4732) the species is recorded from 800–0 fathoms; at one station (4713) from 150–0 fathoms. All the other records refer to catches from 300–0 fathoms.

The temperature range of these thirty-three stations at the surface was 67°–85°; the average was 76.4°.

The frequency is 2% at one station (4638), 1% at seven stations (4583, 4598, 4683, 4701, 4707, 4709, 4721), and less than 1% at the remaining stations.

The species was first recorded by Kofoid (1907a) from Station 4699 of the Expedition, which thus is the type locality. Jörgensen (1923) reported it from the Tyrrhenian Sea.

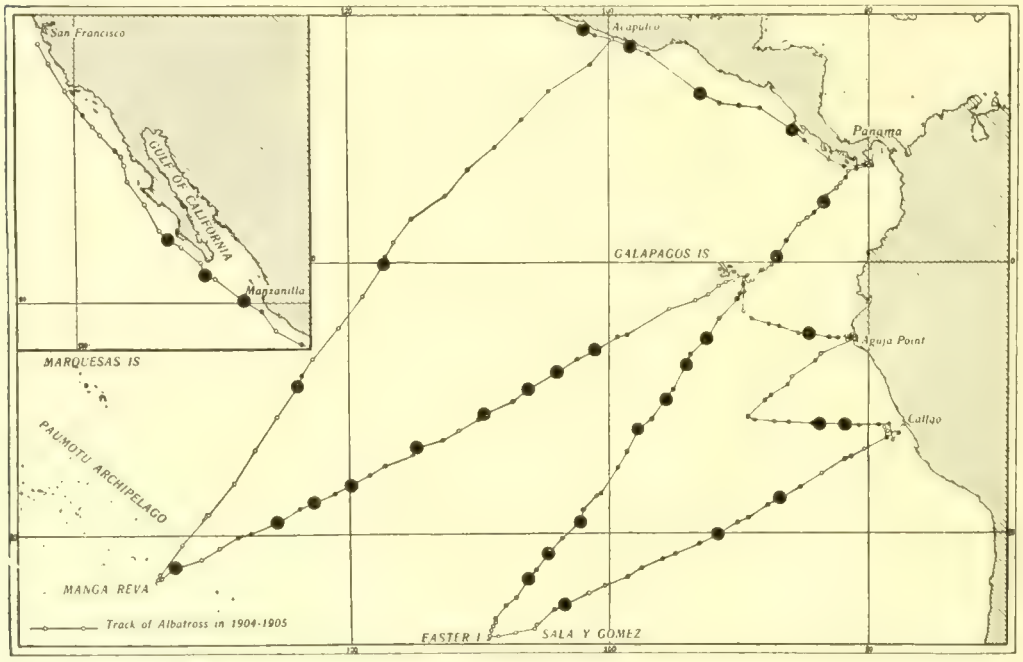

FIGURE 52. — Occurrence of *Amphisolenia extensa* Kofoid. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

This is probably a eupelagic species, extensively distributed in tropical and subtropical seas and sometimes occurring in warm-temperate waters. According to our records, it is fairly evenly distributed throughout the area investigated by the Expedition. Although it appears to be very highly adapted to flotation, it has not been taken as yet in surface catches.

AMPHISOLENIA ELONGATA, sp. nov.

Figure 49: 7, 50: 11

Diagnosis: — With slight sigmoid curvature. Head 1.5 times wider than long. Epitheca moderately convex. Midbody fusiform, gradually merging into

anterior process and antapical or fairly well set off from antapical. Distance from flagellar pore to antapical 3.0 the length of neck. Ratio between length and width of body, 30–35: 1. Antapical gently concave ventrally, six times longer than neck; its posterior end as in *Amphisolenia extensa*. Length, 438–464 μ.

Tropical and subtropical regions of Eastern Pacific.

Description: — The longitudinal axis of the body is slightly sigmoid, with the neck slightly deflected dorsally and the antapical slightly concave ventrally.

The head is inclined anteriorly at an angle of 25°–30°; its axial length is 0.15–0.16 the length of the neck, and it is 1.5 times wider than long (slightly tilted in Figure 49: 7). The anterior face of the epitheca is moderately convex. The transverse furrow is 0.38 as wide as the dorsoventral diameter of the head, flat. The cingular lists are subequal, about 1.5–2.0 times wider than the transverse furrow; the anterior flares anteriorly at an angle of about 10°, the posterior is subhorizontal.

The neck is of moderate length and rather narrow; it is 0.1 the length of the body and 18 times longer than wide. The left sulcal list either ends at the flagellar pore, or it continues a short distance behind the flagellar pore; in the latter case a fission rib is developed.

The midbody is fusiform and merges gradually into the anterior process and antapical, or it is fairly well set off from the antapical. The distance between the flagellar pore and the anterior end of the antapical is 3.0 the length of the neck. The midbody is slender, widest at a distance from the apex equaling 0.27 the length of the body or at a distance from the flagellar pore 1.5 the length of the neck; its greatest width is 0.30–0.40 the length of the neck. The ratio between the length and the greatest width of the body is 30–35: 1.

The antapical is unbranched and slightly concave ventrally. It is rather long, six times longer than the neck or about twice the total length of the anterior process and the midbody; it is as wide as the neck and of uniform width throughout its whole length except near the posterior end where it is slightly club-shaped. The antapex is subtruncate and, as far as known, without spinules.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 438–464 μ (type, 464 μ). Length of head, 9 μ. Length of neck, 45 μ. Length of anterior process and midbody, 129 μ. Width of midbody, 15 μ. Length of antapical, 281 μ.

Variations: — Judging by the two specimens found in the material of the Expedition, the species appears to be rather constant in form and dimensions.

Comparisons: — *Amphisolenia elongata* is founded on outline drawings of two

specimens. Unfortunately, our knowledge of its structural characteristics is incomplete in some respects, *e.g.*, the finer structure of the cingular and sulcal lists and of the transverse furrow is unknown.

The species is probably very closely related to *Amphisolenia extensa*, as is indicated by the great similarity between the posterior portions of the antapicals of these two species (see *A. extensa*, the section on comparisons).

Occurrence: — The species is recorded at two of the 127 stations with a total of two specimens. One of these two stations (4681, the type locality) is on the third, the other (4737) on the fifth line of the Expedition, and both are in the South Equatorial Drift. The sample from Station 4681 was taken from 300–0 fathoms, the other sample (Station 4737) from 300–0 fathoms.

The surface temperatures at these two stations were 68.0° and 81.5°. The frequency is less than 1%.

3. Globifera Group. Both the species belonging to this group, viz., *Amphisolenia globifera* and *A. quadrispina* have been found in the material of the Expedition.

Amphisolenia globifera Stein

Plate 8, fig. 1, 2, 4, 8. Figure 49: 9, 50: 1–5, 53

Amphisolenia globifera Stein, 1883, p. 24, pl. 21, fig. 9, 10. Bütschli, 1885, pl. 55, fig. 4a. Schütt, 1896, p. 28, fig. 40. Murray & Whitting, 1899, tab. 8. Lemmermann, 1899a, p. 373; 1901a, p. 376; 1905a, p. 36. Schröder, 1900a, p. 20. Cleve, 1901a, p. 13; 1903b, *partim*, p. 339. Ostenfeld & Paulsen, 1904, p. 164, 173. Zacharias, 1906, p. 564. Paulsen, 1908, p. 20, fig. 23. Willey, 1909, p. 184, fig. 7. Hjort, 1911, fig. 12: 2. Hensen, 1911, p. 159, 160, tab. 13. Jörgensen, 1923, p. 41, fig. 61.

Amphisolenia globosa Gran, 1912a, p. 935, fig. 8a (*lapsus pennae*); 1912b, fig. 232a.

Amphisolenia tenella Gran, 1912a, p. 935, fig. 8b; 1912b, fig. 232b.

Diagnosis: — Straight or slightly curved. Head subspheroidal or subrectangular, about as long as wide. Epitheca strongly convex. Midbody fusiform, gradually merging into anterior process and antapical. Distance from flagellar pore to antapical 1.4–2.6 the length of neck. Ratio between length and width of body, 9–25: 1. Antapical generally straight, sometimes concave dorsally, 1.3–2.2 times longer than neck; its posterior part knob-like, generally with constriction just in front of knob. Antapex without or with but two spinules. Length, 142–319 μ.

Probably of world-wide distribution in tropical, subtropical, and warm-temperate waters.

Description: — The longitudinal axis of the body is in most cases straight; in one of our specimens (Figure 50: 5) it had a slight and even dorsal concavity; in

another (Figure 50: 2) the posterior half of the antapical was gently concave dorsally.

The head is subhorizontal or somewhat inclined anteriorly, in exceptional cases even at an angle of 25°. It is subspheroidal or subrectangular; its axial length is 0.13 (0.11–0.17; type, 0.15) the length of the neck; and it is about as wide as long. The anterior face of the epitheca is boldly convex. The transverse furrow is 0.30–0.40 as wide as the dorsoventral diameter of the head; generally somewhat convex, sometimes flat or even slightly concave; it has no cross-ridges. The anterior cingular list flares anteriorly at an angle of 20°–30°; the posterior is subhorizontal; both are somewhat wider than the transverse furrow and have simple, equidistant ribs; the anterior list has, on each valve, seven to eight, the posterior, as a rule, six to seven ribs.

The neck is very long, 0.21 (0.17–0.26; type, 0.20) the length of the body, and narrow, 12–22 times longer than wide. The sulcal lists end at or just behind the flagellar pore and have no ribs; the fission rib has not been seen.

The midbody is fusiform and merges gradually into the anterior process and into the antapical. The distance between the flagellar pore and the anterior end of the antapical is 1.9 (1.4–2.6; type, 2.4) the length of the neck. The midbody is of moderate width or more or less slender. It is widest near the middle of the body, as in the type specimen, or somewhat in front of the middle; sometimes it is widest at a distance from the apex equaling two fifths of the length of the body. Its greatest width is 0.19–0.50 the length of the neck; in the type specimen (Stein, 1883, pl. 21, fig. 9) the corresponding ratio is 0.41; in Gran's (1912b) figures 232a and 232b it is 0.50 and 0.20, respectively; in Jörgensen's (1923) figure 61a, 0.30; in our specimens, 0.24 (0.19–0.39). The ratio between the length and the greatest width of the body is 9–25: 1.

The antapical is unbranched, and, in most specimens, straight (see above). It is 1.7 (1.3–2.2; type, 1.6) the length of the neck, in other words, on the average slightly shorter than the total length of the anterior process and the midbody. It is about as wide as or slightly wider than the neck and of uniform width throughout its whole length except at the posterior end, where it expands into a knob-like, globular termination, the diameter of which is 2.0–3.5 the average width of the antapical. Just in front of the knob, the antapical widens slightly, and then contracts into a short neck, before expanding into the knob (Plate 8, fig. 1, 4). This neck-like constriction is frequently easily overlooked because of the fact that it is surrounded by a translucent sheath. The constriction probably does exist in most or perhaps even in all specimens; however, we are not able to make any

final statement on this point. The antapex is either smooth, without any spinules, as in the type specimen, or it has two short, narrow, and pointed spinules. Jörgensen (1923, p. 41) writes about these spinules: "These are small and easily overlooked; also, the species seems to vary in this respect."

The thecal wall is apparently without structure. The posterior part of the antapical is porulate. Along the base of the sulcal lists there is a row of pores; and on the head a number of scattered pores also are to be found.

The nucleus is medium-sized and ellipsoidal. The chromatophores are small, irregular, greenish yellow.

The proportions of six of our specimens and of the specimens drawn by Stein (1883), Gran (1912b), and Jörgensen (1923) were measured.

Dimensions: — Our specimens: Length of body, 142–318 μ (average, 236 μ). Length of head, 4.5–8.0 μ (average, 6.8 μ). Length of neck, 30–68 μ (average, 51 μ). Length of anterior process and midbody, 66–117 μ (average, 94 μ). Width of midbody, 10–16 μ (average, 12 μ). Length of antapical, 42–126 μ (average, 86 μ). The size of the type specimen (Stein, 1883, pl. 21, fig. 9) is not known. Stein does not give the magnification of this figure; however, in an introductory note to the explanations of the plates, he states that his magnifications range from 450 to 690 diameters. The length of body of the type specimen is therefore between 214 μ and 328 μ. The specimens represented by Gran (1912b, fig. 232a and b) are 179 μ and 153 μ long, respectively. Greatest width of midbody, 20 μ and 7 μ, respectively. Jörgensen (1923, p. 40) states that the specimens examined by him measured about 200 μ in length or somewhat less.

Variations: — As conceived in the present paper, *Amphisolenia globifera* exhibits a rather remarkable variability. The following characters are more or less strikingly variable: — the length of the body, the shape of the longitudinal axis of the body, the shape and inclination of the head, the relative length of the neck, the relative width of the midbody, the relative length of the antapical, and the shape and structure of the posterior part of the antapical. Future investigations, based on a material richer than ours, may prove it necessary and feasible to divide this species into two or more systematic units.

Comparisons: — Some of the specimens found in the material of the Expedition and referred to *Amphisolenia globifera* in this paper, agree fairly closely with the type specimen of this species as drawn by Stein (1883, pl. 21, fig. 9). On the other hand, the determination of some of our remaining specimens is somewhat doubtful (see the previous section). It may be noted that in none of our specimens is the anterior cingular list quite so wide as in Stein's figures of the type specimen.

The specimen of this species figured by Hjort (1911, fig. 12: 2) agrees very closely with the type specimen. The same is true with regard to the specimens represented by Gran (1912b, fig. 232a; reproduced in Gran, 1912a, fig. 8a) and by Jörgensen (1923, fig. 61). On the other hand, the specimen figured by Gran (1912b, fig. 232b; reproduced in Gran, 1912b, fig. 8b) under the name of *Amphisolenia tenella* differs very strikingly from the type specimen of *A. globifera* in the narrowness of its midbody (see the following section).

The small size, the straight longitudinal axis of the body, and the unbranched antapical appear to be primitive features of this species. The gradual merging of the midbody into the antapical and the differentiation of the posterior part of the antapical are probably later acquisitions.

Amphisolenia globifera is undoubtedly very closely related to *A. quadrispina*. This relationship is indicated especially by the globular shape of the posterior part of the antapical in these species. *A. globifera* is easily distinguished from *A. quadrispina* by its smaller size (142–318 μ as compared with 630 μ) and by having two or no antapical spinules instead of four.

Synonymy: — The species was established by Stein (1883) under the name of *Amphisolenia globifera*. It is the type species of the genus. Of later writers only Hjort (1911) and Jörgensen (1923) have contributed to our knowledge of the structure of the species. Bütschli (1885), Schütt (1896), Paulsen (1908), and Willey (1909) give reproductions of Stein's figures of the type specimen.

With regard to *Amphisolenia globifera* Cleve (1903b), see the section on the distribution of this species.

In Gran (1912a and b) the name of *Amphisolenia globosa* was used for this species, evidently due to a *lapsus pennae*.

We have considered it most advisable, for the time being, to accept Jörgensen's (1923, p. 41) decision that *Amphisolenia tenella* Gran (1912b, fig. 232b) is identical with *A. globifera*. The characters on which *A. tenella* evidently is founded (no diagnosis or description accompany the figure), are variable to such an extent as to render a differentiation of these two forms impossible at the present time. However, it seems to be far from improbable that future investigations, based on a material richer than ours, will prove *A. tenella* and *A. globifera* specifically distinct.

Occurrence: — The species is recorded at seventeen of the 127 stations. There are 3, 3, 0, 4, 6, and 1 stations on the six lines of the Expedition. Of these seventeen stations, one (4571) is in the California Current; one (4590) is in the Mexican Current; one (4613) is in the Panamic Area; three (4662, 4666, 4668) are in the

Peruvian Current; one (4699) is in the Easter Island Eddy; one (4713) is in the Galapagos Eddy; eight (4701, 4711, 4717, 4721, 4722, 4724, 4732, 4733) are in the South Equatorial Drift; one (4742) is in the South Equatorial Current. At one station (4733) the species was found in the stomach of Salpa from surface waters, the only record from the surface in the material of the Expedition. At three stations (4662, 4666, 4717) it occurred in catches from 800–0 fathoms; at one station (4701) in a catch from 800–0 fathoms as well as in catches from 300–0 fathoms; at one station (4713) in a catch from 150–0 fathoms as well as in one from 300–0 fathoms. The remaining records refer to catches from 300–0 fathoms only.

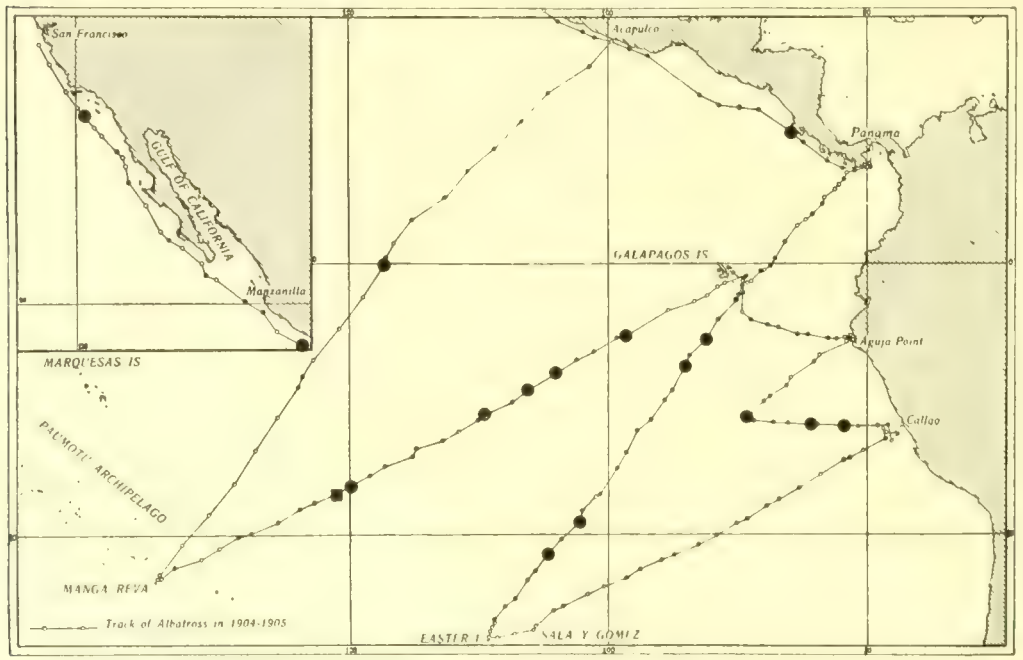

FIGURE 53.— Occurrence of *Amphisolenia globifera* Stein. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

The temperature range of these seventeen stations at the surface was 67°–83°; the average was 74.5°.

A frequency of 1% is recorded at seven stations (4571, 4613, 4662, 4666, 4668, 4713, 4717). In the remaining cases the frequency is less than 1%.

The species was first recorded by Stein (1883) "aus dem Atlantischen Meer." Hjort (1911) and Gran (1912b) mentioned it as taken in the North Atlantic by the MICHAEL SARS Expedition, 1910. It was recorded from the Gulf Stream, lat. 59° N., long. 22° W., by Ostenfeld and Paulsen (1904); from the Sargasso Sea, lat. 34°–30° N., long. 39°–32° W., by Murray and Whitting (1899); from the

North and South Equatorial Currents of the Atlantic by Hensen (1911); from the Bay of Cadiz, near the Straits of Messina, and east of Sardinia by Jörgensen (1923); from the Malay archipelago by Cleve (1901a). The samples of Ostenfeld and Paulsen (1904), Murray and Whitting (1899), and Cleve (1901a) were taken near the surface. Jörgensen (1923) found the species in catches from 80–200 meters.

The species occurs in waters of the following temperatures and salinities: — Ostenfeld and Paulsen (1904): temperature, 49.3°; salinity, probably about 35.30; Murray and Whitting (1899): temperature 66°–60°; Cleve (1901a): the temperature range of six samples, 83.7°–77.5°, average 82.2°; the salinity range of these samples was 33.06–31.62, and the average 32.46.

Murray and Whitting (1899), Ostenfeld and Paulsen (1904), and Cleve (1901a) do not give any information as to the structure of their specimens. In Hjort (1911), Gran (1912b), and Jörgensen (1923), on the other hand, drawings of this species are to be found.

Cleve (1903b) reported "*Amphisolenia globifera* Stein (incl. *A. bidentata* Schröder)" from the Red Sea, lat. 20° N., long. 39° E., and from the Arabian Sea, lat. 21° N., long. 62° E., and lat. 19°–15° N., long. 59°–52° E. The temperature range of five surface stations was 81.3°–74.3°, with an average of 75.6°; the salinity range of these stations was 38.78–36.02, and the average 36.94. These localities have not been included among those given above because of the fact that *A. globifera* Cleve (1903b) possibly may be a *lapsus pennae* for *A. palmata* (see Schröder, 1906a, p. 371). In any case, Cleve has confused two distinct species.

This species is eupelagic and has a world-wide distribution in tropical, subtropical, and warm-temperate waters, and only occasionally is carried by currents to the colder regions of the seas. Our record stations are fairly evenly distributed over the district investigated by the Expedition.

Amphisolenia quadrispina Kofoid

Plate 9, fig. 2–4. Figure 49: 10, 50: 9

Amphisolenia quadrispina Kofoid, 1907a, p. 200, 201, pl. 14, fig. 86.

Diagnosis: — Straight; head subspheroidal, 1.1–1.5 times wider than long. Epitheca strongly convex. Midbody fusiform, gradually merging into anterior process and antapical. Distance from flagellar pore to antapical 4.6 the length of neck. Ratio between length and width of body, 40–45: 1. Antapical straight, about five times longer than neck; its posterior part knob-like, with constriction just in front of knob. Antapex with four spinules. Length, 607–693 μ.

Eastern tropical and subtropical Pacific.

Description: — The longitudinal axis of the body is straight. The head is subspheroidal and inclined anteriorly at an angle of 10°–15°; its axial length is 0.20 the length of the neck; and it is about as wide as long or even 1.5 times wider than long. The anterior face of the epitheca is strongly convex. The transverse furrow is 0.50 as wide as the dorsoventral diameter of the head, either slightly convex, flat, or gently concave; it has no cross-ridges. The cingular lists flare anteriorly at an angle of 10°–20°, or the posterior is subhorizontal; they are about as wide as or somewhat wider than the transverse furrow, and each of them has, on each valve, six to eight simple, equidistant ribs.

The neck is rather long and narrow; it is 0.09 the length of the body, and 15 times longer than wide. The sulcal lists end at or just behind the flagellar pore and have no ribs; the fission rib has not been seen.

The midbody is fusiform and merges gradually into the anterior process and into the antapical. The distance between the flagellar pore and the anterior end of the antapical is 4.6 the length of the neck. The midbody is very slender, widest at a distance from the apex equaling two fifths of the length of the body, or at a distance from the flagellar pore three times longer than the neck; its greatest width is 0.23 the length of the neck. The ratio between the length and the greatest width of the body is 40–45: 1.

The antapical is unbranched and straight. It is about five times longer than the neck and slightly longer than the total length of the anterior process and the midbody. It is about as wide as the neck and of uniform width throughout its whole length except at its posterior end where it expands into a knob-like, globular termination, the diameter of which is between three and four times the average width of the antapical. Just in front of the knob, the antapical widens slightly, and then contracts into a short neck before expanding into the knob. The antapex is characterized by four equidistant, short, narrow, and pointed spinules, placed in such a way that in fission two go with each valve.

The thecal wall is apparently without structure. The posterior part of the antapical is porulate.

The nucleus is rather large, elongated, and somewhat irregular. In the midbody as well as in the antapical there are numerous small, spheroidal chromatophores.

In the girdle and on the epitheca of one specimen was found a moderate number of small spheroidal bodies of about the same type as the phaeosomes of other genera of this tribe. Such bodies have not been found in any other species of Amphisolenia and their significance is unknown.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 607–693 μ (type, 630 μ). Length of head, 11 μ. Length of neck, 60 μ. Length of anterior process and midbody, 270 μ. Width of midbody, 13 μ. Length of antapical, 287 μ.

Variations: — Apart from variations in size, the species appears to be rather constant.

Comparisons: — The description given above is based on the type material. See the section on the comparisons of *Amphisolenia globifera*.

Occurrence: — This species is recorded at eleven of the 127 stations. There are 6, 1, 0, 1, 2, and 1 stations on the six lines of the Expedition. Of these eleven stations, three (4574, 4580, 4583) are in the California Current; one (4605) is in the Mexican Current; three (4613, 4617, 4634) are in the Panamic Area; three (4711, 4722, 4728) are in the South Equatorial Drift; one (4742) is in the South Equatorial Current. At one station (4728) the species is recorded from 800–0 fathoms as well as from 300–0 fathoms. At the remaining stations it is recorded from 300–0 fathoms only.

The temperature range of these eleven stations at the surface was 69°–85°; the average was 77.7°.

The frequency is less than 1% except at two stations (4574, 4617), where it is 1%.

The species never has been found except in the material of the Expedition. It was first recorded by Kofoid (1907a) from Stations 4613 and 4722 of the Expedition. However, the type specimen (Kofoid, 1907a, pl. 14, fig. 86) is from Station 4711 of the Expedition, which thus is the type locality.

The most remarkable peculiarities in the distribution of this species in the Eastern Pacific, according to our data, are its relatively frequent occurrence in the California Current and its absence from the Peruvian Current. It appears to be eupelagic in warm seas.

4. Bispinosa Group. Both the species belonging to this group, viz., *Amphisolenia bispinosa* and *A. curvata*, have been found in the material of the Expedition.

Amphisolenia bispinosa Kofoid

Plate 9, fig. 1, 6, 7, 8. Figure 49: 12

Amphisolenia bispinosa Kofoid, 1907a, p. 197, 201, pl. 14, fig. 85.

Diagnosis: — With moderate sigmoid curvature. Head 2.2 times wider than long. Epitheca slightly convex. Midbody fusiform, passing imperceptibly into

anterior process and antapical. Ratio between length and width of body, 35–40: 1. Antapical with gentle and even ventral concavity; its posterior part very slightly inflated. Antapex rounded in lateral view; with two stout, pointed, lateral spinules, one on each valve. Length, 646–652 μ.

Eastern tropical and subtropical Pacific.

Description: — The longitudinal axis of the body has a moderate sigmoid curvature, due to the slight dorsal deflection of the neck and the gentle and even ventral concavity of the antapical. The ventral deflection of the antapical is about 5°.

The head is inclined anteriorly at an angle of 30°; its axial length is 0.22 the length of the neck, and it is 2.2 times wider than long. The anterior face of the epitheca is slightly convex. The transverse furrow is 0.14 as wide as the dorsoventral diameter of the head, flat or slightly convex, and has, on each valve, five to six almost equidistant cross-ridges. The anterior cingular list is about three times wider than the transverse furrow, flares anteriorly at an angle of 25° and has, on each valve, five to six fairly regularly spaced, simple ribs. The posterior cingular list is somewhat narrower, subhorizontal, and has about the same number of similar ribs.

The neck is of moderate length, 0.07 the length of the body, and about seven times longer than wide. On each valve, near the middle, it has a low, narrow, somewhat irregular, sometimes broken, longitudinal ridge, which in some individuals extends from the girdle to near the flagellar pore. The sulcal lists extend a little behind the flagellar pore and have no ribs; the fission rib has not been seen.

The midbody is fusiform, and merges very gradually into the anterior process and into the antapical. It is very slender and widest at a distance from the apex equaling two fifths of the length of the body or at a distance from the flagellar pore four times longer than the neck; its greatest width is 0.43 the length of the neck. The ratio between the length and the greatest width of the body is 35–40: 1.

The antapical is unbranched, and gently and evenly concave ventrally. Its length cannot be determined, even approximately, because of the fact that it merges so gradually into the midbody. It grows gradually narrower posteriorly, but its posterior end, which is somewhat wider than the neck, is slightly inflated. In lateral view the antapex is rounded; in dorsoventral view it is truncate. It has two stout, pointed, lateral antapical spinules, one on each valve; the length of these spinules approaches the distal width of the antapical.

The thecal wall is almost without structure. Along the base of each of the

sulcal lists and on either side of the dorsal suture line of the neck there is a row of closely set pores. On the posterior part of the antapical there is a row of pores on either side of the dorsal as well as of the ventral suture line and also some scattered pores (see also the description of the neck).

The nucleus is elongated and somewhat irregular. The chromatophores are numerous, small, and ellipsoidal.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 646–652 μ (type, 652 μ, not 670 μ as stated in the original description). Length of head, 11 μ. Length of neck, 43 μ. Length of anterior process, midbody, and antapical, 587 μ. Width of midbody, 20 μ.

Variations: — In the few specimens examined as yet, this species appears to be rather constant.

Comparisons: — The description given above is based on the type material.

The simple, unbranched type of the antapical appears to be a primitive feature of this species. On the other hand, the slenderness of the midbody, the very gradual merging of the midbody into the antapical, and the sigmoid curvature of the longitudinal axis of the body probably are later differentiations.

Amphisolenia bispinosa presumably is closely related to *A. curvata*. This relationship is indicated by the sigmoid curvature of the longitudinal axis of the body, by the shape of the posterior part of the antapical, by the lateral position of the spinules on the antapex, and by the longitudinal ridges on the neck. *A. bispinosa* differs from *A. curvata* mainly in the small size of its body, in the narrowness of its midbody, and in the relatively large size of its antapical spinules.

Occurrence: — *Amphisolenia bispinosa* is recorded at eight of the 127 stations. There are 3, 2, 0, 1, 2, and 0 stations on the six lines of the Expedition. Of these eight stations, one (4583) is in the California Current; one (4605) is in the Mexican Current; one (4617) is in the Panamic Area; two (4662, 4668) are in the Peruvian Current; one (4713) is in the Galapagos Eddy; two (4736, 4737) are in the South Equatorial Drift. At one station (4662) the species is recorded from 800–0 fathoms. All the remaining records refer to catches from 300–0 fathoms.

The temperature range of these eight stations at the surface was 67°–85°; the average was 77.2°.

The frequency is less than 1% except at one station (4668) where it is 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4605 of the Expedition, which thus is the type locality.

Amphisolenia curvata Kofoid

Plate 9, fig. 5, 9, 10. Figure 49: 11

Amphisolenia curvata Kofoid, 1907a, p. 197, pl. 14, fig. 87.

Diagnosis: — With rather strong sigmoid curvature. Head 1.5 times wider than long. Epitheca flat or slightly convex. Midbody fusiform, merging gradually into anterior process but rather well set off from antapical. Approximate distance from flagellar pore to antapical, 4.7 the length of neck. Ratio between length and width of body, 12–13: 1. Antapical with rather strong, even, ventral concavity, approximately four times longer than neck; its posterior end very slightly widened. Antapex rounded with minute spinule on left valve (normally with one on each valve?). Length, 463 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body has a rather strong sigmoid curvature, due to the moderate dorsal deflection of the neck and the rather strong and even ventral concavity of the antapical. The ventral deflection of the antapical is about 7°.

The head is inclined anteriorly at an angle of 20°; its axial length is 0.24 the length of the neck, and it is 1.5 times wider than long. The anterior face of the epitheca is flat or slightly convex. The transverse furrow is 0.25 as wide as the dorsoventral diameter of the head and flat; it has, on each valve, five to six almost equidistant cross-ridges. The cingular lists are twice as wide as the transverse furrow and flare anteriorly at an angle of 10°; each of them has, on each valve, six fairly regularly spaced, simple ribs.

The neck is of moderate length, 0.10 the length of the body, and seven to eight times longer than wide. On each valve, near the middle, it has a low, narrow, somewhat irregular, longitudinal ridge, which in the type specimen extends from the girdle to the flagellar pore. The sulcal lists extend to the flagellar pore and have no ribs. An accessory list, arising from the originally free edge of the left sulcal list, extends along the posterior third of the left sulcal list and ends somewhat behind the flagellar pore; its greatest width, which is subequal to that of the neck, is at the flagellar pore; anteriorly and posteriorly it tapers, rather suddenly posteriorly, very slowly anteriorly; at the flagellar pore it has a cross-rib, the fission rib.

The midbody is fusiform and merges gradually into the anterior process but is rather well set off from the antapical. The approximate distance between the flagellar pore and the anterior end of the antapical is 4.7 the length of the neck.

The midbody is of moderate width, widest at a distance from the apex equaling two fifths of the length of the body, or at a distance from the flagellar pore three times the length of the neck; its greatest width is 0.8 the length of the neck. The ratio between the length and the greatest width of the body is 12–13: 1.

The antapical is unbranched, with a rather strong and even ventral concavity, and approximately four times longer than the neck or 0.8 the total length of the anterior process and the midbody. Posteriorly it grows gradually narrower, except near the posterior end where it widens very slightly; its posterior end is about 1.5 times wider than the neck. In lateral view the antapex is rounded; in dorsoventral view it probably is truncate in completely developed specimens with a minute lateral spinule on each valve; in the type specimen the right valve is rounded and without any spinule, the left truncate with a minute lateral spinule.

The thecal wall is almost without structure. On the posterior end of the antapical there is a row of pores on either side of the dorsal as well as of the ventral suture line and also some scattered pores. In front of these, there is an irregular reticulum of low and narrow ridges (see also the description of the neck). The porulation of the neck is probably as in *Amphisolenia bispinosa*, but there is no information on this point.

The nucleus is small and ellipsoidal. The chromatophores are numerous, ellipsoidal and spheroidal.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 463 μ. Length of head, 11 μ. Length of neck, 45 μ. Length of anterior process, midbody, and antapical, 397 μ. Approximate length of anterior process and midbody, 220 μ. Width of midbody, 35 μ. Approximate length of antapical, 177 μ.

Comparisons: — The description given above is based on the type specimen. As to the relationships between this species and the other members of this genus, see *Amphisolenia bispinosa*, the section on comparisons.

Occurrence: — *Amphisolenia curvata* is recorded at only one of the 127 stations. This station (4605) is on the first line of the Expedition and in the Mexican Current. The depth is 300–0 fathoms, the surface temperature 85°, and the frequency less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4605 of the Expedition, which thus is the type locality.

5. Schröderi Group. All the four species that belong to this group have been found in the material of the Expedition. They have been treated in this paper in the following order indicative of relationships: — *Amphisolenia schröderi, A. clavipes, A. complanata*, and *A. truncata*.

Amphisolenia schröderi Kofoid

Plate 10, fig. 2–4. Figure 49: 15

Amphisolenia schroederi Kofoid, 1907a, p. 201, pl. 13, fig. 81.

Diagnosis: — Straight. Head spheroidal, about as long as wide. Epitheca boldly convex. Midbody fusiform merging very gradually into anterior process and antapical. Ratio between length and width of body, 25: 1. Antapical almost straight; its posterior part slightly bent ventrally and to the right and not or only slightly widened. Antapex rounded in dorsoventral view and truncate in lateral view; with two short spinules, one dorsal and one ventral, both probably belonging to left valve. Length, 510 μ.

Tropical and subtropical regions of Eastern Pacific.

Description: — The longitudinal axis of the body is almost straight; only the posterior part of the antapical is slightly bent. The head is spheroidal, about as wide as long or but slightly wider than long; its axial length is 0.18–0.19 the length of the neck. The anterior face of the epitheca is boldly convex. The transverse furrow is about 0.5 as wide as the dorsoventral diameter of the head, somewhat convex, and has on each valve one to four cross-ridges. The anterior cingular list is about twice as wide as the transverse furrow, flares anteriorly at an angle of 30°–40°, and has, on each valve, five to six equidistant, simple ribs. The posterior cingular list is slightly narrower, subhorizontal or inclined anteriorly about 10°, and has no ribs.

The neck is rather long, 0.13 the length of the body, and nine times longer than wide. The sulcal lists end at the flagellar pore and have no ribs.

The midbody is fusiform and merges very gradually into the anterior process and into the antapical. It is rather slender and widest at a distance from the apex equaling two fifths of the length of the body or at a distance from the flagellar pore about twice as long as the neck; its greatest width is 0.30 the length of the neck. The ratio between the length and the greatest width of the body is 25: 1.

The antapical is unbranched and almost straight; its posterior part is slightly bent ventrally and to the right. Its length cannot be determined even approximately, because of the fact that it merges so gradually into the midbody. It

grows gradually narrower posteriorly, and its posterior part is not or only slightly widened; its width near the posterior end is about 1.5 the average width of the neck. In dorsoventral view the antapex is rounded, in lateral view it is truncate. It has two short spinules, one dorsal and one ventral, both probably belonging to the left valve; the length of the spinules is about 0.25 the dorsoventral width of the posterior end of the antapical.

The thecal wall is apparently without structure. On the posterior part of the antapical there is a row of fine pores on either side of the ventral suture line, and a similar row is found along the base of each of the sulcal lists.

The nucleus and the chromatophores are as in *Amphisolenia clavipes.*

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 510 μ. Length of head, 10 μ. Length of neck, 68 μ. Length of anterior process, midbody, and antapical, 431 μ. Width of midbody, 20 μ.

Comparisons: — The description given above is based on the type material The straight longitudinal axis of the body and the simple, unbranched type of the antapical are primitive features of this species. The slenderness and the very gradual merging of the midbody into the antapical probably are advances in differentiation.

The closest-known relative of *Amphisolenia schröderi* is undoubtedly *A. clavipes.* Indeed, it even may be questionable whether or not these two forms are specifically distinct, and their specific separation should be regarded as tentative. *A. schröderi* differs from *A. clavipes* mainly in the following respects: — (*1*) its midbody is slightly narrower, with the ratio between length and width of body 25: 1, as compared with 15–19: 1; (*2*) the posterior portion of its antapical generally is somewhat less inflated and less strongly bent to the right (see *A. clavipes,* the section on variations); (*3*) its transverse furrow and its epitheca appear to lack porulation; (*4*) it is decidedly larger, 510 μ as compared with 230–263 μ. The difference in size appears to be the most important. However, it should be remembered that dwarfs and giants have been found in a rather large number of species in Dinophysoidae.

Another close relative of *Amphisolenia schröderi* is *A. complanata.* The former species differs from the latter mainly in the smaller width of its head (ratio between length and width of its head about 1: 1 as compared with 1: 3) and in the smaller size of its antapical spinules.

Amphisolenia schröderi is probably also rather closely related to *A. truncata,* from which it is easily distinguished by the narrowness of its head and by having

antapical spinules (as to the systematic value of the latter difference, see *A. truncata*, the section on comparisons).

Amphisolenia schröderi, *A. clavipes*, *A. complanata*, and *A. truncata* form a presumably natural systematic group, the Schröderi group. Their closest relatives, outside the group, probably are to be found in the Palmata group.

Occurrence: — *Amphisolenia schröderi* is recorded at seven of the 127 stations. There are 2, 1, 0, 1, 3, and 0 stations on the six lines of the Expedition. Of these seven stations, two (4598, 4605) are in the Mexican Current; one (4659) is in the Peruvian Current; four (4701, 4736, 4737, 4739) are in the South Equatorial Drift. At one station (4737) the species is recorded from 100–0 fathoms as well as from 300–0 fathoms. All the other records refer to catches from 300–0 fathoms only.

The temperature range of these seven stations at the surface was 69°–85°; the average was 78.8°.

The frequency is less than 1% at all stations.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4737 of the Expedition, which thus is the type locality.

Amphisolenia clavipes Kofoid

Plate 11, fig. 8–11. Figure 49: 13, 50: 7

Amphisolenia clavipes Kofoid, 1907a, p. 197, pl. 14, fig. 90. Doflein, 1909, p. 464, fig. 403d; 1911, p. 531, fig. 462d; 1916, p. 437, fig. 374d.

Diagnosis: — Almost straight except near antapex. Head spheroidal, about as long as wide. Epitheca boldly convex. Midbody fusiform, merging very gradually into anterior process and antapical. Ratio between length and width of body, 15–19: 1. Antapical almost straight except near antapex where it is slightly curved ventrally and more or less strongly bent to the right; posterior end but slightly or more or less strikingly widened. Antapex rounded in dorsoventral view and truncate in lateral view; with two short spinules, one dorsal and one ventral, both probably on left valve. Length, 230–263 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is almost straight; the neck is slightly deflected dorsally and the posterior end of the antapical is more or less bent.

The head is spheroidal, about as wide as long, or rather slightly wider than long (width: length, 1.0–1.3: 1); its axial length is 0.23 (0.19–0.27) the length of

the neck. The anterior face of the epitheca is boldly convex. The transverse furrow is about 0.5 as wide as the dorsoventral diameter of the head, somewhat convex or flat and has, on each valve, three to four cross-ridges. The anterior cingular list is about as wide as or somewhat wider than the transverse furrow, flares anteriorly at an angle of 30°–40°, and has, on each valve, four to six equidistant, simple ribs. The posterior cingular list is generally slightly narrower, subhorizontal or inclined anteriorly at an angle of 10°–20° and has no or only a few simple ribs.

The neck is rather long, 0.14–0.15 the length of the body, and six to seven times longer than wide. The sulcal lists end at or just behind the flagellar pore and have no ribs; the fission rib has not been seen. Sometimes they have about the same shape as in Plate **10**, figure 3, of *Amphisolenia schröderi;* sometimes a rather broad accessory list arises near the flagellar pore from the originally free edge of the left sulcal list and continues somewhat behind the pore (Plate **11**, fig. 8).

The midbody is fusiform and merges very gradually into the anterior process and into the antapical. It is rather slender or of moderate width and widest somewhat in front of the middle; its greatest width is 0.38–0.45 the length of the neck. The ratio between the length and the greatest width of the body is 15–19: 1.

The antapical is unbranched and almost straight except posteriorly; its posterior part is slightly curved ventrally and more or less strongly bent to the right. Its length cannot be determined even approximately because of the fact that it merges so gradually into the midbody. It grows gradually narrower posteriorly, except near the antapex where it sometimes is slightly or moderately widened; its width near the antapex somewhat exceeds the average width of the neck. In dorsoventral view the antapex is rounded, in lateral view it is truncate; it has two short spinules, one dorsal and one ventral, both probably belonging to the left valve. The length of the spinules is about 0.25 the dorsoventral width of the posterior end of the antapical.

The thecal wall has the same structure as in *Amphisolenia schröderi*, but the transverse furrow and the epitheca are porulate.

The nucleus is large, elongated, and somewhat irregular. The chromatophores are rather large and cylindrical (Plate **11**, fig. 11).

The proportions of five specimens from the material of the Expedition were measured.

Dimensions: — Length of body, 230–263 μ (average, 248 μ; type, 230 μ). Length of head, 7.0–8.5 μ (average and type, 8.0 μ). Length of neck, 31–39 μ

(average, 36 μ; type, 31 μ). Length of anterior process, midbody, and antapical in the type specimen, 190 μ. Width of midbody, 12–16 μ (average, 15 μ; type, 12 μ).

Variations: — The species appears to be relatively constant. The shape of the posterior portion of the antapical is the most variable character. Sometimes, as in the type specimen (Figure 50: 7), this portion is rather strikingly inflated, and strongly and rather abruptly bent to the right. In other cases these peculiarities are less developed, and this portion even may have almost the same shape as in *Amphisolenia schröderi, i.e.*, it may be but slightly or even not at all inflated and only slightly bent to the right (Plate **10**, fig. 4).

Comparisons: — The description given above is based on the type material. With regard to the relationships of this species, see *Amphisolenia schröderi*, the section on comparisons (p. 401).

Synonymy: — The species was established by Kofoid (1907a) under the name of *Amphisolenia clavipes*. Reproductions of Kofoid's (1907a) figure of the type specimen are given by Doflein (1909, 1911, 1916).

Occurrence: — *Amphisolenia clavipes* is recorded at two of the 127 stations. These two stations (4736, 4737) are on the fifth line of the Expedition and in the South Equatorial Drift. At Station 4737 the species is recorded from 100–0 fathoms and from 300–0 fathoms; at Station 4736 from 300–0 fathoms only.

The surface temperatures of these two stations were 81.0° and 81.5°, respectively. The frequency is less than 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4736 of the Expedition, which thus is the type locality.

Amphisolenia complanata, sp. nov.

Plate **10**, fig. 5, 7, 9. Figure 49: 16

Diagnosis: — With slight sigmoid curvature. Head three times wider than long. Epitheca flat. Midbody fusiform, merging very gradually into anterior process and antapical. Ratio between length and width of body, 32–39: 1. Antapical with very slight ventral concavity; approximately five to eight times longer than neck; its posterior end slightly widened, almost straight. Antapex rounded in dorsoventral view and truncate in lateral view; with two rather strong spinules, one dorsal and one ventral, both probably on left valve. Length, 600–785 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is slightly sigmoid, the neck

somewhat deflected dorsally, and the antapical evenly and very slightly concave ventrally.

The head is inclined anteriorly at an angle of 30°; its axial length is about 0.12 the length of the neck, and it is three times wider than long. The anterior face of the epitheca is flat or but slightly convex. The transverse furrow is 0.25 as wide as the dorsoventral diameter of the head, somewhat convex, and has, on each valve, six to seven equidistant cross-ridges. The cingular lists are about twice as wide as the transverse furrow or somewhat less; the anterior is inclined anteriorly at an angle of 20° and has, on each valve, eight equidistant, simple ribs; the posterior is subhorizontal and has, on each valve, six to seven similar ribs.

The neck is of moderate length, 0.06–0.09 the length of the body, and eight to nine times longer than wide. The sulcal lists sometimes extend to the flagellar pore and have no ribs (Plate **10**, fig. 5); sometimes an accessory list of moderate width arises near the flagellar pore from the originally free edge of the left sulcal list and continues somewhat behind the pore. The accessory list has a fission rib at the pore (compare Plate **11**, figure 8, of *Amphisolenia clavipes*).

The midbody is fusiform and merges very gradually into the anterior process and into the antapical. The approximate distance between the flagellar pore and the anterior end of the antapical is five to eight times the length of the neck. The midbody is very slender, widest at a distance from the apex equaling one third of the length of the body, or at a distance from the flagellar pore 2.5–3.5 times the length of the neck; its greatest width is 0.35–0.40 the length of the neck. The ratio between the length and the greatest width of the body is 32–39: 1.

The antapical is unbranched, with a very slight ventral concavity; its posterior part is almost straight. It is approximately five to eight times longer than the neck and subequal to the total length of the anterior process and the midbody. Posteriorly it grows slightly narrower, except near the posterior end where it widens slightly; its posterior end is about 1.8–2.2 times wider than the neck. In dorsoventral view the antapex is rounded; in lateral view it is truncate; it has two rather strong spinules, one dorsal and one ventral, both probably on the left valve; the length of the spinules is about 0.50 the dorsoventral width of the posterior end of the antapical or somewhat less.

The thecal wall is apparently without structure. On the posterior part of the antapical there is a row of fine pores on either side of the dorsal as well as of the ventral suture line and some pores between these rows. On the neck no pores have been observed.

The nucleus and the chromatophores are probably as in *Amphisolenia clavipes*.

The proportions of two specimens were measured.

Dimensions: — Length of body, 600–785 μ (type, 600 μ). Length of head, 7.0–7.5 μ (type, 7.0 μ). Length of neck, 46–53 μ (type, 53 μ). Length of anterior process, midbody, and antapical of type specimen, 432 μ. Width of midbody, 20 μ.

Variations: — In the two specimens examined, this species was constant, except in the size of the body and the relative length of the neck.

Comparisons: — The species certainly is very closely related to *Amphisolenia schröderi* and *A. clavipes*, as is shown by the similar differentiation of the posterior portion of the antapical in these three species. It is easily distinguished from these two species by the greater width of its head and by the larger size of its two antapical spinules. However, *A. complanata* probably is most closely related to *A. truncata*, from which it differs mainly in having antapical spinules. For further discussion of the relationships of these four species, see *A. schröderi*, the section on comparisons (p. 401).

Occurrence: — *Amphisolenia complanata* is recorded at two of the 127 stations. These two stations (4737, 4739) are on the fifth line of the Expedition and in the South Equatorial Drift. The depth is 300–0 fathoms. Station 4739 is the type locality.

The surface temperatures of these two stations were 79.0° and 81.5° respectively. The frequency is less than 1%.

Amphisolenia truncata Kofoid and Michener

Plate 11, fig. 1, 12. Figure 49:14

Amphisolenia truncata Kofoid & Michener, 1911, p. 294. Jörgensen, 1923, p. 40, 43, fig. 58.

Diagnosis: — Almost straight or with slight sigmoid curvature. Head 2.0–2.5 times wider than long. Epitheca moderately convex. Midbody fusiform, merging very gradually into anterior process and antapical. Approximate distance from flagellar pore to antapical four to five times longer than neck. Ratio between length and width of body, 28–38: 1. Antapical straight or with slight ventral concavity; approximately 6.0–6.5 times longer than neck; its posterior end not widened, straight. Antapex truncate in lateral view, without spinules. Length, 650–663 μ.

Eastern tropical Pacific, and Mediterranean.

Description: — The longitudinal axis of the body is almost straight or gently sigmoid, with the neck somewhat deflected dorsally and the antapical straight or with a slight ventral concavity.

The head is inclined anteriorly at an angle of 30°; its axial length is 0.19–0.20 the length of the neck; and it is 2.0–2.5 times wider than long. The anterior face of the epitheca is moderately convex. The transverse furrow is 0.25 as wide as the dorsoventral diameter of the head, flat, and has, on each valve, six to seven equidistant cross-ridges. The cingular lists are 1.5–2.0 as wide as the transverse furrow; the anterior is inclined anteriorly at an angle of 20° and has, on each valve, seven or eight simple, equidistant ribs; the posterior is subhorizontal and may possibly lack ribs (Jörgensen, 1923, fig. 58b). In the type specimen no ribs were observed in the cingular lists; they probably were overlooked.

The neck is of moderate length, 0.08 the length of the body, and eight to nine times longer than wide. The sulcal lists are as in *Amphisolenia complanata*.

The midbody is fusiform and merges very gradually into the anterior process and into the antapical. The approximate distance between the flagellar pore and the anterior end of the antapical is four to five times longer than the neck. The midbody is very slender, widest at a distance from the apex equaling 0.29–0.33 the length of the body, or at a distance from the flagellar pore two to three times longer than the neck; its greatest width is 0.34–0.44 the length of the neck. The ratio between the length and the greatest width of the body is 28–38: 1.

The antapical is unbranched, straight, or with a very slight ventral concavity; its posterior part is straight. It is approximately 6.0–6.5 times longer than the neck and 1.2–1.8 times the total length of the anterior process and the midbody. Posteriorly it grows slightly narrower; its posterior end is not widened and is 1.3–1.8 times wider than the neck. The antapex is truncate in lateral view and lacks ribs. Sometimes it is surrounded by a (protoplasmic?) sheath (see Jörgensen, 1923, fig. 58c).

The thecal wall is apparently without structure. On the posterior part of the antapical there is a row of fine pores on either side of the dorsal as well as of the ventral suture line. A row of fine pores is also found along the base of each of the sulcal lists.

The proportions of the type specimen and of the specimen drawn by Jörgensen (1923, fig. 58) were measured.

Dimensions: — Type specimen: Length of body, 650 μ. Length of head, 9 μ. Length of neck, 50 μ. Length of anterior process, midbody, and antapical, 584 μ. Approximate length of antapical, 317 μ. Width of midbody, 17 μ. Jörgensen's

(1923) specimen: " Length 663 μ, max. breadth 24 μ, or 36% of the length." According to measurements made from his figures 58a and b: Length of body, 675 μ. Length of head, 11 μ. Length of neck, 55 μ. Length of anterior process, midbody, and antapical, 600 μ. Approximate length of antapical, 380 μ. Width of body, 28 μ.

Variations: — The two specimens examined by us exhibit variations in the degree of curvature of the longitudinal axis of the body, in the ratio between the length and the width of the body, and in the relative length of the antapical.

Comparisons: — The description given above is based on the type specimen.

The specimen described and figured by Jörgensen (1923) under the name of *Amphisolenia truncata* agrees very closely with the type specimen of this species.

It is, of course, an open question as to whether or not the absence of antapical spinules in *Amphisolenia truncata* is primitive. However, the fact that antapical spinules are present in *A. inflata,* which probably is the most primitive known species of this genus, and in almost all the other known members of this genus, representing different evolutionary lines, and the fact that *A. truncata* in several respects appears to be highly differentiated rather than primitive seem to indicate that the absence of antapical spinules is secondary in this species.

Amphisolenia truncata probably is closely related to *A. schröderi, A. clavipes,* and *A. complanata.* It differs from these three species in not having any antapical spinules. From *A. schröderi* and *A. clavipes* it also differs in the greater width of its head.

The closest-known relative of *Amphisolenia truncata* is undoubtedly *A. complanata.* It may even be questionable whether or not the two forms are specifically distinct, and their systematic separation should be regarded as tentative. They differ mainly in the presence or absence of antapical spinules. Both the antapical spinules in *A. complanata* probably belong to one valve. Binary fission in this species might therefore be followed by a stage of short duration in which one of the daughter individuals is without antapical spinules. Is *A. truncata* based on a representative of *A. complanata* in which the antapical spinules have not yet developed following binary fission? It may be of a certain interest in this connection that in the specimen of *A. truncata* figured by Jörgensen (1923, fig. 58c) the posterior portion of the antapical appears to be surrounded by a hyaline sheath. Such a sheath may be a sign of a recent cell division.

For further discussion about the relationships of these species, see the section on the comparisons of *Amphisolenia schröderi* (p. 401).

Occurrence: — *Amphisolenia truncata* is recorded at only one of the 127 stations. This station (4733) is on the fifth line of the Expedition and in the South

Equatorial Drift. The frequency is less than 1%; only one specimen is recorded. This specimen was found in the stomach of a Salpa from surface waters, at a temperature of 80°.

The species was first recorded by Kofoid and Michener (1911) from Station 4733 of the Expedition, which thus is the type locality. Later, Jörgensen (1923) reported one specimen from the Balearic Sea, off the coast of Africa.

6. Palmata Group. All the five species that belong to this group have been found in the material of the Expedition. They have been treated in this paper in the following order indicative of relationships: — *Amphisolenia bidentata*, *A. lemmermanni*, *A. palmata*, *A. palaeotheroides*, and *A. asymmetrica*.

Amphisolenia bidentata Schröder

Figure 54: 1–4, 55, 56: 1

Amphisolenia bidentata Schröder, 1900a, p. 20, 35, pl. 1, fig. 16a–c; 1900b, p. 3; 1906a, p. 323, 324, 326, 328, 331, 332, 333, 338, 339, 371, 374; 1906b, p. 262; 1909, p. 211; 1911, p. 3, 4, 25, 38. Ostenfeld & Schmidt, 1901, p. 162. Schmidt, 1901, p. 138. Lemmermann, 1901a, p. 376. Ostenfeld, 1902, p. 21; 1915, p. 4. Entz, 1902b, p. 94; 1905, p. 112. Cleve, 1903b, *partim*, p. 339. Okamura, 1907, *partim*, p. 127, *non* pl. 3, fig. 15; 1912, p. 20. Karsten, 1907, p. 252, 256, 259, 264, 267, 269, 270, 271, 274, 280, 284, 287, 288, 292, 297, 306, 307, 308, 311, 315, 325, 334, 335, 336, 337, 339, 342, 344, 345, 346, 347, 350, 352, 353, 354, 356, 357, 359. Stüwe, 1909, p. 254, 288. Kofoid & Michener, 1911, p. 293. Schiller, 1911a, p. 52; 1912, p. 27. Pavillard, 1916, *partim*, p. 61. Forti, 1922, p. 112, 113, 192, 209, fig. 123. Jörgensen, 1923, p. 39, 40, fig. 56.
Amphisolenia sp., Chun, 1903, p. 76, fig. e.

Diagnosis: — Slightly or moderately sigmoid. Head 2.0–3.0 times wider than long. Epitheca gently convex. Midbody fusiform, merging very gradually into anterior process and antapical. Approximate distance from flagellar pore to antapical, 3.5–5.5 times longer than neck. Ratio between length and width of body, 30.3–67.7: 1. Antapical approximately 8.0–13.5 the length of neck, with gentle ventral concavity, its posterior part bent to the right 25°–40°, and twisted ventrally 90°; at point of bending, left valve has strong, short, pointed spinule, which makes posterior part of antapical foot-like. Seen ventrally (torsion), antapex is widened, two to three times wider than average width of antapical, truncate; with two spinules on left valve, one on each corner, but none on right valve. Length, 716–990 μ.

Of world-wide distribution, in tropical, subtropical, and warm-temperate waters.

Description: — The longitudinal axis of the body is slightly or moderately sigmoid, with the neck somewhat deflected dorsally, and the antapical having a gentle ventral concavity. The posterior part of the antapical is always bent to the right and twisted ventrally.

The head is inclined anteriorly at an angle of 30°–50°; its axial length is 0.16 (0.15–0.19) the length of the neck; and it is 2.0–3.0 times wider than long. The anterior face of the epitheca is gently convex, or in some cases rather flat. The transverse furrow is 0.20–0.30 as wide as the dorsoventral diameter of the head, gently convex flat, or slightly concave and has, on each valve, about three to five cross-ridges. The cingular lists are 1.2–2.0 as wide as the transverse furrow; both may be inclined anteriorly at an angle of 10°–25° or both may be subhorizontal; each of them has, on each valve, five to nine simple, equidistant ribs.

The neck is of moderate length and width, 0.05–0.08 the length of the body and eight to fourteen times longer than wide. The sulcal lists either end at the cytopharyngeal pore or they continue somewhat behind it; in some specimens they appear to lack ribs, in others the left one has a fission rib at the flagellar pore.

The midbody is fusiform and merges very gradually into the anterior process and into the antapical. The approximate distance between the flagellar pore and the anterior end of the antapical is 3.5–5.5 times longer than the neck. The midbody is very slender, widest at a distance from the apex equaling about one fifth to one fourth the length of the body, or at a distance from the flagellar pore 1.5–3.5 the length of the neck; its greatest width is 0.27–0.67 the length of the neck. The ratio between the length and the greatest width of the body is 46.3 (30.3–67.7): 1 (21: 1 in a parasitized specimen).

The antapical is unbranched, approximately 8.0–13.5 the length of the neck and 1.5–3.0 times longer than the total length of the anterior process and the midbody. It is gently concave ventrally, and its posterior part is bent to the right at an angle of 25°–40° and twisted ventrally 90°. Our data are insufficient to establish whether or not this torsion is a constant characteristic of this species. At the point of bending the left valve has a short, strong, pointed, heel-like spinule, which gives to the posterior part of the antapical a foot-like appearance. In lateral view (torsion) the foot-like part is not as wide as or is rather slightly wider than the average width of the antapical, about 2.5–4.5 times longer than wide and more or less rounded distally. Seen ventrally (torsion) the posterior part of the "foot" is truncate and about two to three times wider than the antapical just in front of the foot. The antapex has two fairly strong and short, pointed spinules on the left valve, one on each corner, but no spinule on the right valve. The average width of the antapical is subequal to or somewhat exceeds that of the neck. Near the antapex the antapical has what appears to be a protoplasmic sheath.

The thecal wall is apparently without structure. The posterior part of the

antapical is porulate. Along the base of each of the sulcal lists there is a row of pores, and on the head a number of scattered pores are to be found.

The chromatophores are located near the center of the midbody and are light yellowish brown (Ostenfeld and Schmidt, 1901).

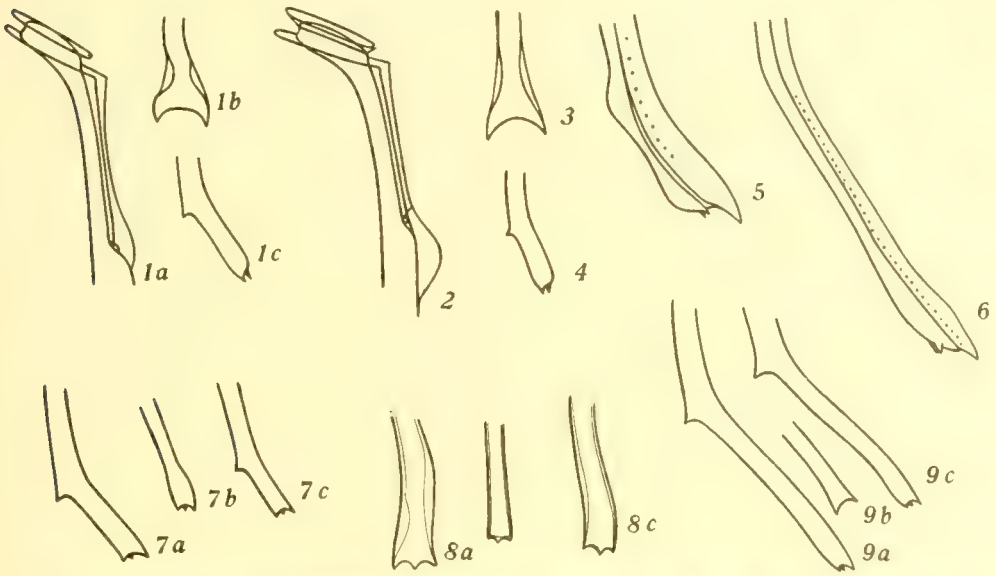

FIGURE 54.— 1–4, *Amphisolenia bidentata* Schröder. × 430. 1a-c, from Station 4737 (100–0 fathoms). 1a, right lateral view of anterior portion of body; 1b and 1c, posterior portion of antapical of specimen represented by 1a; 1b is seen in right lateral view and shows ventral deflection; 1c is seen in dorsal view and shows a comparatively long "foot"; torsion disregarded. 2, right lateral view of anterior portion of body; left sulcal list has a fission rib and continues for a considerable distance beyond flagellar pore. Station 4740 (300–0 fathoms). 3, right lateral view of posterior portion of antapical; straight. Station 4730 (300–0 fathoms). 4, dorsal view of posterior portion of antapical; "foot" relatively short. Station 4713 (300–0 fathoms). 5, *A. palmata* Stein, dorsal view of posterior portion of antapical following fission; right (old) valve with its distal spinule fully developed; left (new) valve without heel spinule and with but slightly developed distal spinules. × 900. Station 4734 (300–0 fathoms). 6, *A. asymmetrica* Kofoid, dorsal view of posterior portion of antapical of type specimen of *A. dolichocephalica* Kofoid, *i.e.*, of a specimen following fission; right (old) valve has its distal spinule fully developed; left (new) valve without heel spinule and with rather slightly developed distal spinules. × 900. Station 4728 (300–0 fathoms). 7–9, *A. thrinax* Schütt. × 430. 7–8, from a specimen from Station 4594 (300–0 fathoms); 7, in right lateral view; 8, in ventral view. 7a and 8a represent posterior portion of antapical stem, with relatively short "foot," and with heel-spinule and three distal spinules; 7b and 8b represent distal portion of second antapical branch, without heel-spinule and with three distal spinules; 7c and 8c, distal portion of first antapical branch, with relatively short "foot," and with heel-spinule and three distal spinules. 9, from a specimen, in right lateral view, from Station 4737 (300–0 fathoms). 9a, posterior portion of antapical stem, with relatively long "foot," and with heel-spinule and three distal spinules; 9b, distal portion of second antapical branch, without heel-spinule and with two distal spinules on left valve; 9c, distal portion of first antapical branch, with relatively long "foot," and with heel-spinule and three distal spinules.

The length and the width of the body were measured in twenty of our specimens and the proportions of the head and of the neck in fourteen of our specimens. All the proportions were measured in only three of our specimens and in the type specimen and the specimen reproduced by Jörgensen (1923, fig. 56).

Dimensions: — Our specimens: Length of body, 716–990 μ (average, 822 μ). Length of head, 6–10 μ (average, 8 μ). Length of neck, 43–53 μ (average, 47 μ). Width of midbody, 14.0–29.6 μ (average, 18.8 μ); in a parasitized specimen it was 34.8 μ. Type specimen (Schröder, 1900a, pl. 1, fig. 16a): Length of body, 773 μ. Length of head, 8.5 μ. Length of neck, 48 μ. Length of anterior process and midbody, 178 μ. Length of antapical, 537 μ. Width of midbody, 18 μ. Jörgensen's (1923, fig. 56) specimen: Length of body, 920 μ. Length of head, 10 μ. Length of neck, 53 μ. Length of anterior process and midbody, 280 μ. Length of antapical 580 μ. Width of midbody, 20 μ.

Variations: — The length of the body and the width of the midbody are rather variable. Variability is also found in other characters, *e.g.*, in the width and relative length of the foot-like posterior part of the antapical. It may be pertinent to mention in this connection that in our narrowest specimen (ratio between the length and the width of the body, 67.7: 1) one of the two thecal valves was new; in other words, this specimen had been taken shortly after the separation of the two daughter cells in binary fission. This may indicate that the width of the midbody increases with the age of the individuals (see the section on the reproduction of this genus).

Comparisons: — The specimens found in the material of the Expedition show, as previously mentioned, some variability. However, most of them agree closely with *Amphisolenia bidentata* as figured and described by Schröder (1900a).

With regard to the specimen figured by Okamura (1907, pl. 3, fig. 15) under the name of *Amphisolenia bidentata*, see the following section. The specimen represented by Jörgensen (1923, fig. 56) under this name agrees very closely with the type specimen.

The unbranched antapical is a primitive feature of this species. The slight sigmoid curvature of the longitudinal axis of the body, the narrowness, and the gradual merging of the midbody into the antapical, as well as the differentiation of the posterior part of the antapical, are probably later acquisitions.

Amphisolenia bidentata is certainly very closely related to *A. lemmermanni*. Indeed, these two forms are so similar that their systematic separation should be regarded as tentative. They differ from each other mainly in the length of the body and in the width of the midbody. The length of *A. bidentata* is 716–990 μ (average, 822 μ); that of *A. lemmermanni*, 522–669 μ (average, 572 μ). The ratio between the length and the width of the body is 30.3–67.7 (average, 46.3): 1 in *A. bidentata;* in *A. lemmermanni* it is 13.4–33.8 (average, 23.4): 1 (see the previous section). Furthermore, the posterior part of the antapical is twisted ventrally at

an angle of about 90° in *A. bidentata* and appears always to be without torsion in *A. lemmermanni*. However, our data are not sufficient to establish whether or not the last difference is constant. In order to settle the question as to whether or not these two forms are specifically distinct, it will be necessary to resort to biometric determinations on more extensive material. Our statements of the lengths and the relative widths of these forms are based on thirty-six specimens, twenty of which were referable to *A. bidentata* and sixteen to *A. lemmermanni*.

Another close relative of *Amphisolenia bidentata* is undoubtedly *A. palmata*. The former species differs from the latter mainly in its slightly larger size and in having two, instead of three, spinules on the antapex; in other words, in not having any antapical spinule on the right valve. The systematic separation of these two forms should be regarded as an open question (see Schröder, 1906a, p. 371, and Ostenfeld, 1915, p. 4). This statement is based on the following facts. The antapical mid-spinule in *A. palmata* belongs to the right valve, the two remaining spinules on the antapex to the left valve. Figure 54: 5 shows that, in this species, there is a stage following binary fission in which the antapical spinules of the new valve are very slightly or not at all developed. We have, therefore, reason to suppose that one of the two daughter individuals passes through a stage characterized by the same number and arrangement of the antapical spinules as in *A. bidentata*. It also may be mentioned that in *A. bidentata* and in *A. lemmermanni* the posterior part of the antapical is characterized by what appears to be a hyaline sheath, while such a sheath has not been found in *A. palmata*. The presence of a sheath of this kind may possibly be a sign of recent binary fission (see *A. asymmetrica*, the section on comparison. These facts seem to indicate that *A. palmata* may be an older developmental stage of *A. bidentata*. However, this assumption appears to be contradicted by the following facts: — (*1*) *A. bidentata* is more frequent than *A. palmata* in the material of the Expedition, although the differentiation of thecal structures following binary fission has been found to take place very rapidly in all the dinoflagellates that have been studied in this respect; (*2*) in *A. schröderi*, *A. clavipes*, and *A. complanata* the antapex appears to have the same number and arrangement of spinules as in *A. bidentata*.

Other close relatives of *Amphisolenia bidentata* are *A. palaeotheroides* and *A. asymmetrica*, both of which are easily distinguished from the first-mentioned species by having three, instead of two, spinules on the antapex. *A. asymmetrica* is also characterized by the extreme width of its head.

Amphisolenia bidentata, *A. lemmermanni*, *A. palmata*, *A. palaeotheroides*, and *A. asymmetrica* form a natural systematic group, the PALMATA group. Their

closest relatives, outside the group, are probably to be found on the one hand in the SCHRÖDERI group, on the other in the BIFURCATA group (see the section on the subdivisions of the genus, p. 360).

Synonymy: — The species was established by Schröder (1900a) under the name of *Amphisolenia bidentata*. Of the writers who have treated this species only Jörgensen (1923) gives drawings by means of which the determinations may be checked. Forti (1922) gives a reproduction of Schröder's figure of the type specimen.

Cleve (1903b, p. 339) wrote *Amphisolenia bidentata* as a synonym of *A. globifera*. This decision was justly rejected by Schröder (1906a, p. 371) as well as by other writers who have treated these species. Cleve's (1903b) data have accordingly not been included in our section on the distribution of *A. bidentata*.

The specimen figured by Chun (1903, p. 76, fig. e) under *Amphisolenia* sp. probably belongs to *A. bidentata*, but the drawing does not permit a certain determination.

The specimen reproduced by Okamura (1907, pl. 3, fig. 15) under the name of *Amphisolenia bidentata* is referable to *A. lemmermanni*. It is only 666 μ long, the ratio between the length and the width of its body is 29: 1, and the posterior part of its antapical is not twisted ventrally. According to statements in the text, the specimens examined by Okamura were 0.1 mm. long and 0.02 mm. wide. These measurements probably are wrong; they presumably stand for 1000 μ and 20 μ. The latter figures indicate that some of the specimens examined by Okamura (1907) belonged to *A. bidentata*. However, their assignment must be regarded as uncertain.

Ostenfeld (1915, p. 4) suggested as a possibility that *Amphisolenia palmata* Cleve (1901a) from the Malay Archipelago may be identical with *A. bidentata*. Cleve (1901a) recorded only *A. palmata* from these waters, Ostenfeld (1915) only *A. bidentata*. Since no data bearing on this question have yet been published, Cleve's determination has been accepted in this paper.

Among the specimens of *Amphisolenia bidentata* found by Pavillard (1916, p. 61) there was one that agreed with *A. palmata*. "Cependant une récolte du 27 décembre 1914 m'a donné, au milieu d'une douzaine d'échantillons typiques, un individu muni d'un troisième denticule antapical, reproduisant ainsi la disposition caractéristique de l'*A. palmata*." This specimen, which was referred to *A. bidentata* by Pavillard (1916), has been referred to *A. palmata* in the present paper. Pavillard (1916) considered the independence of these two species as probable.

With regard to Jörgensen's (1923, p. 40) statement that *Amphisolenia palmata* and *A. bidentata* have been confused by previous authors, see below, the section on the distribution.

Occurrence: — The species is recorded at sixty-three of the 127 stations. There are 13, 7, 4, 10, 21, and 8 stations on the six lines of the Expedition. Of these sixty-three stations, three (4574, 4580, 4583) are in the California Current; seven (4587, 4588, 4590, 4592, 4594, 4596, 4605) are in the Mexican Current; six (4609, 4613, 4617, 4634, 4638, 4640) are in the Panamic Area; five (4646, 4648, 4659, 4667, 4676) are in the Peruvian Current; seven (4689, 4691, 4694, 4695, 4697, 4699, 4700) are in the Easter Island Eddy; one (4713) is in the Galapagos Eddy; twenty-eight (4679, 4701, 4705, 4708, 4712, 4717, 4718, 4719, 4720, 4721, 4722, 4723, 4724, 4725, 4727, 4728, 4729, 4730, 4731, 4732, 4733, 4734, 4736, 4737, 4738, 4739, 4740, 4741) are in the South Equatorial Drift; three (4742, 4743, 4540) are in the South Equatorial Current; two (4541, 4542) are in the Equatorial Counter Current; one (4543) is in the North Equatorial Current. At twenty-four stations (4588, 4592, 4596, 4640, 4676, 4694, 4700, 4708, 4712, 4718, 4720, 4723 [Salpa stomachs], 4725, 4727, 4729, 4731, 4733 [Salpa stomach], 4738, 4741, 4743, 4540, 4541, 4542, 4543) the species was found in surface catches only. At four stations (4583, 4638, 4648, 4740) it was found in surface catches as well as in catches from 300–0 fathoms; at one station (4737) in a catch from 100–0 fathoms as well as in one from 300–0 fathoms; at one station (4713) in a catch from 150–0 fathoms as well as in one from 300–0 fathoms; at seven stations (4689, 4701, 4717, 4721, 4724, 4728, 4732) in catches from both 800–0 fathoms and 300–0 fathoms. All the remaining records refer to catches from 300–0 fathoms only.

The species is also recorded from Acapulco Harbor near the Mexican Current; this station is not included in the 127 stations mentioned above.

The temperature range of these sixty-three stations at the surface was 68°–95°; the average was 77.0°. At the twenty-eight stations in the surface catches of which the species was found, the surface temperature ranged from 69° to 84°; the average was 77.7°. At Acapulco the temperature was 83°.

For the surface samples the following frequencies are recorded: — 2% at four stations (4592, 4720, 4725, 4741); 1% at twelve stations (4583, 4596, 4638, 4640, 4648, 4676, 4712, 4718, 4731, 4738, 4743, 4543); in the remaining cases less than 1%. For the samples from 100, 150, 300, or 800 fathoms to the surface the records of frequency are as follows: 8% at one station (4648); 6% at one station (4739); 4% at three stations (4713, 4719, 4740); 3% at six stations (4587, 4590, 4689, 4697, 4728, 4737); 2% at eight stations (4583, 4659, 4701, 4717, 4721, 4724, 4734,

4736); 1% at fourteen stations (4580, 4605, 4609, 4613, 4617, 4638, 4646, 4667, 4691, 4695, 4722, 4730, 4732, 4742); in the remaining cases less than 1%.

The species was first recorded by Schröder (1900a) from the Gulf of Naples, which thus is the type locality. In the Atlantic Ocean it was found by Stüwe (1909) at lat. 3° 50′ N., long. 26° 15′ W.; by Schröder (1909) at St. Thomas in the West Indies; and by Jörgensen (1923) in the Bay of Cadiz. Jörgensen (1923, p.

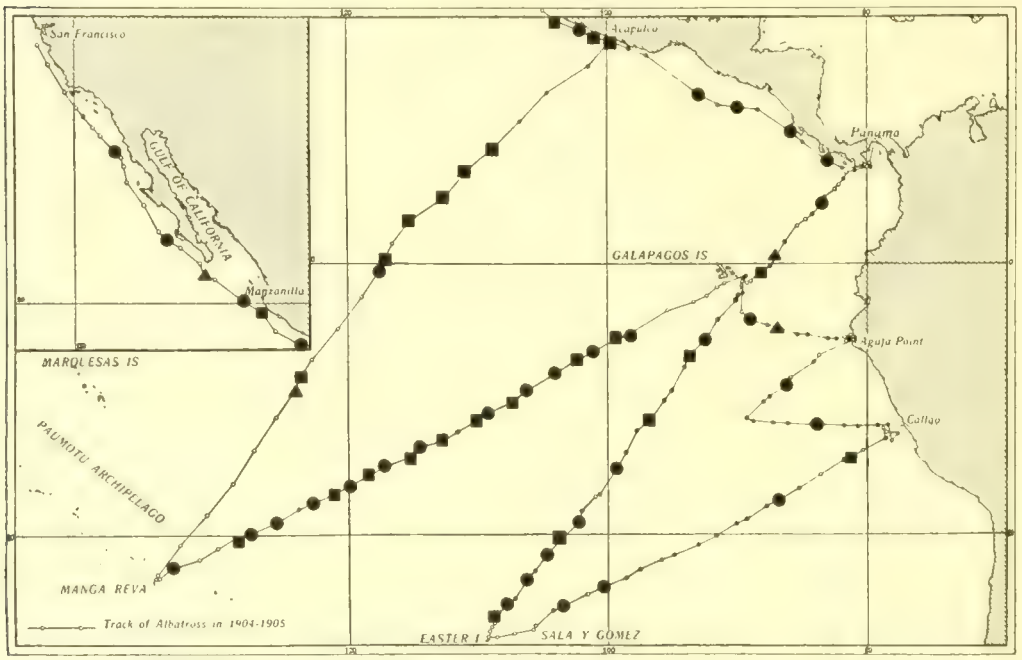

FIGURE 55.— Occurrence of *Amphisolenia bidentata* Schröder. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

40) states that *Amphisolenia bidentata* "has a wide distribution in the Atlantic, both in the northern and the southern parts," and that the Atlantic distribution of *A. palmata* is unknown, as this species "has been confused with and included under *A. bidentata*." These statements, although very plausible, are not supported by any published records (see also the section on the comparisons of *A. bidentata*, p. 412). Jörgensen (1923) found *A. bidentata* to be the most common species of this genus and distributed throughout the Mediterranean. In the Gulf of Lyons it was found by Pavillard (1916); in the Ligurian Sea by Forti (1922); in the Adriatic Sea by Entz (1902b, 1905), Schröder (1911), and Schiller (1911a, 1912). In the Red Sea it was found by Ostenfeld and Schmidt (1901), Schröder (1906a), and Karsten (1907); in the Gulf of Aden by Ostenfeld and Schmidt (1901), Schröder (1906a), and Karsten (1907); in the Arabian Sea by Ostenfeld and

Schmidt (1901) and by Schröder (1906a); in the Indian Ocean by Ostenfeld (1902), Schröder (1906a), and Karsten (1907). Karsten recorded it from twenty-six of the stations of the VALDIVIA Expedition in the Indian Ocean, between lat. 8° N. and lat. 10° S., and from near the west coast of Sumatra to near the east coast of Africa. From the East Indies it was recorded by Schröder (1906a) and Ostenfeld (1915); from the Gulf of Siam by Schmidt (1901); from Japanese waters by Schröder (1906a) and Okamura (1907, 1912); from the eastern part of the Pacific, at lat. 33° N., long. 135° W., and lat. 25° N., long. 140° W., by Schröder (1906a).

Most of the records referred to above were from surface catches (see the section on the distribution of the genus, p. 349). The only records of closing-net hauls published as yet are those of Karsten (1907) from Station 268 of the VALDIVIA Expedition, lat. 9° 6′ N., long. 53° 41′ E., viz., hauls from 17–0 m., 24–4 m., 30–0 m., 63–46 m., and 105–88 m.; all the individuals are reported as living.

The species occurs in waters of the following temperatures and salinities: — Ostenfeld and Schmidt (1901): temperature range of four stations, 79.0°–84.5°; average, 80.5°. Ostenfeld (1902): temperature, 82.4°; salinity, 33.8. Okamura (1912): temperature, 76.5°–76.8°. Stüwe (1909): temperature, 80.1°. Forti (1922): the temperature range of four stations, 55.6°–65 .6°, and the average, 61.0°.

Of the writers who have contributed to our knowledge of the distribution of this species only Schröder (1900a), Okamura (1907), and Jörgensen (1923) give any information or figures by means of which the accuracy of their determinations may be judged. The figure given by Forti (1922) is a reproduction of Schröder's (1900a) drawing of the type specimen. With regard to Okamura's (1907) determinations, see above.

For a discussion of Ostenfeld's (1915) suggestion that the specimens recorded by Cleve (1901a) from the Malay Archipelago under the name of *Amphisolenia palmata* would belong to *A. bidentata*, see above.

Amphisolenia bidentata evidently is one of the most common species of its genus, of world-wide distribution in tropical, subtropical, and warm-temperate seas and sometimes fairly rich in individuals (*e. g.*, it was found to be "common" in the Arabian Sea by Schröder, 1906a). In the material of the Expedition it is by far the most common representative of this genus. The most outstanding peculiarities of its distribution in the Eastern Pacific, according to the records of the Expedition, are its eupelagic habitat and its frequent occurrence in all regions except in the Peruvian Current and in the part of the South Equatorial Drift which is nearest to this current. Among all the species of this genus it is the most frequent in surface waters.

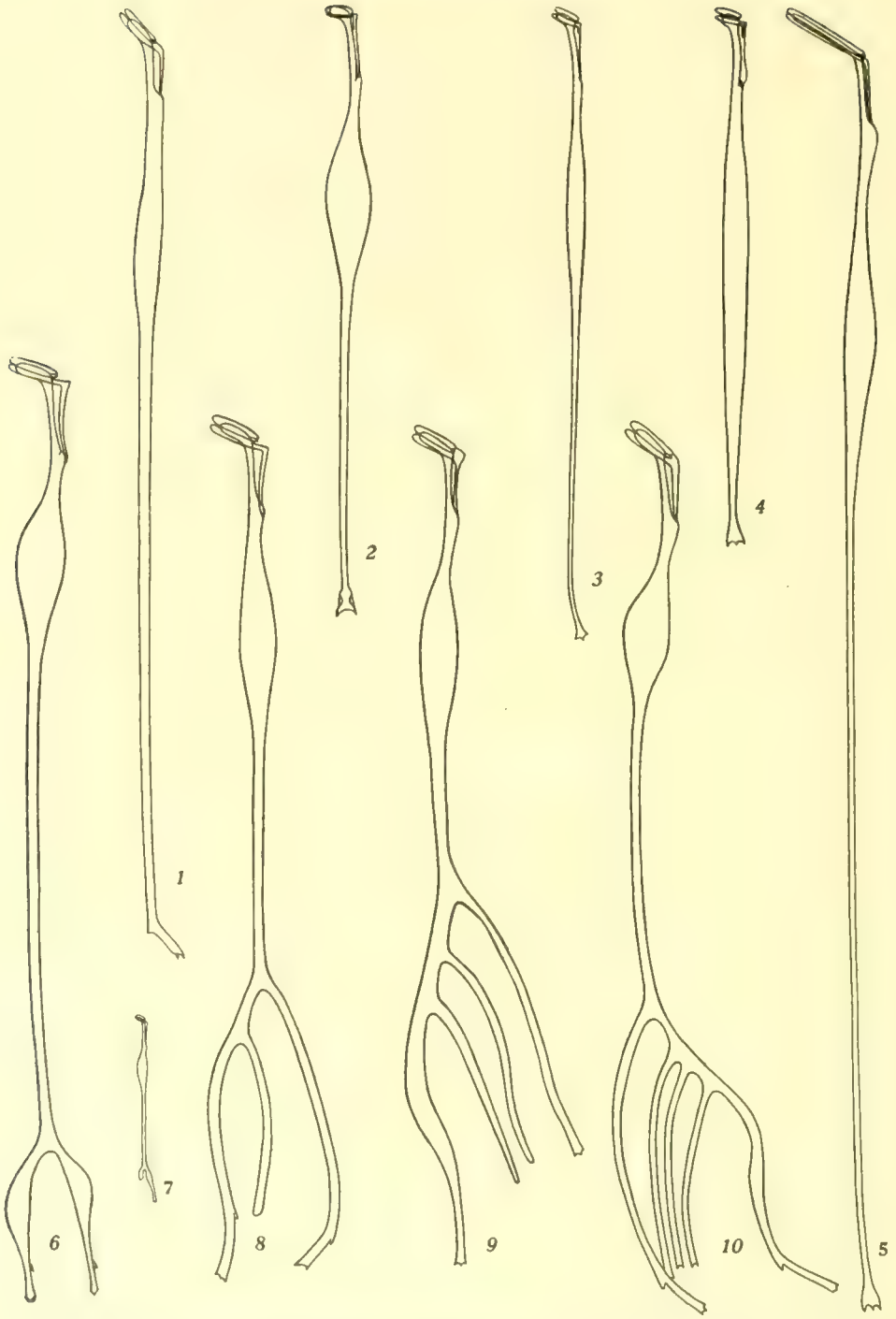

FIGURE 56.—1, *Amphisolenia bidentata* Schröder. Station 4730 (300–0 fathoms). 2, *A. lemmermanni* Kofoid. Station 4730 (300–0 fathoms). 3, *A. palmata* Stein. Station 4734 (300–0 fathoms). 4, *A. palaeotheroides* Kofoid. Station 4732 (300–0 fathoms). 5, *A. asymmetrica* Kofoid. Station 4732 (300–0 fathoms). 6, *A. bifurcata* Murray and Whitting. Station 4699 (300–0 fathoms). 7, *A. projecta* Kofoid. Station 4701 (300–0 fathoms). 8, *A. thrinax* Schütt. Station 4737 (300–0 fathoms). 9, *A. quadricauda* Kofoid. Station 4695 (300–0 fathoms). 10, *A. quinquecauda* Kofoid. Station 4739 (300–0 fathoms). Figure 2, 4, 5, 7, 9, and 10 from type specimens. Right lateral view. × 150.

Amphisolenia lemmermanni Kofoid

Plate 9, fig. 11, 12. Figure 50: 8, 56: 2, 57

Amphisolenia lemmermanni Kofoid, 1907a, p. 199, pl. 14, fig. 88, 89.
Amphisolenia bidentata Okamura, 1907, *partim*, p. 137, pl. 3, fig. 15a–d.

Diagnosis: — Almost straight or with gentle sigmoid curvature. Head 2.0–2.5 times wider than long. Epitheca gently convex. Midbody fusiform, merging very gradually into anterior process and antapical. Approximate distance from flagellar pore to antapical, 3.5–4.5 times longer than neck. Ratio between length and width of body, 13.4–33.8: 1. Antapical approximately six to nine times longer than neck, straight or with gentle ventral concavity; its posterior part of the same shape and structure as in *Amphisolenia bidentata* but generally not twisted ventrally. Length, 522–669 μ.

Tropical and subtropical regions of the Pacific.

Description: — The longitudinal axis of the body is almost straight or gently sigmoid, with the neck somewhat deflected dorsally, and the antapical having a slight ventral concavity. The posterior part of the antapical is bent to the right.

The axial length of the head is 0.17 (0.15–0.20) the length of the neck; and the head is 2.0–2.5 times wider than long.

The neck is of moderate length and width, 0.07–0.10 the length of the body and seven to eleven times longer than wide.

The approximate distance between the flagellar pore and the anterior end of the antapical is 3.5–4.5 times longer than the neck. The midbody is slender or of moderate width, widest at a distance from the flagellar pore equaling about one third to one fourth the length of the body, or at a distance from the flagellar pore 2.0–2.5 the length of the neck; its greatest width is 0.40–0.72 the length of the neck. The ratio between the length and the greatest width of the body is 23.4 (13.4–33.8): 1. It should be mentioned that the type specimen is by far the widest specimen of this species recorded as yet; the ratio between its length and its greatest width is 13.4: 1, while in the next-widest specimen it is only 19.2: 1.

The antapical is six to nine times longer than the neck and 1.5–2.0 times longer than the total length of the anterior process and the midbody. It is almost straight or slightly concave ventrally. Its posterior part seems always to lack the ventral torsion. However, our data are not sufficient to establish whether this lack of torsion is a constant characteristic of this species.

The nucleus is large and ovoidal. There are a great number of small spheroidal chromatophores scattered throughout the whole body.

In the characters not mentioned above the species agrees with *Amphisolenia bidentata.*

The length and the width of the body were measured in sixteen of our specimens and the proportions of the head and of the neck in seven of our specimens. All the proportions were measured in only two of our specimens and in the specimen reproduced by Okamura (1907, pl. 3, fig. 15a).

Dimensions: — Our specimens: Length of body, 522–669 μ (average, 572 μ; type, 567 μ). Length of head, 7–10 μ (average, 8.4 μ; type, 9.5 μ). Length of neck, 45–53 μ (average, 49 μ; type, 53 μ). Length of anterior process and midbody 169–197 μ (type, 197 μ). Length of antapical, 308–400 μ (type, 308 μ). Width of midbody, 20–42 μ (average, 25.5 μ; type, 42 μ). Okamura's (1907, pl. 3, fig. 15) specimen: Length of body, 666 μ. Length of head, 8.5 μ. Length of neck, 50 μ. Length of anterior process and midbody, 199 μ. Length of antapical, 405 μ. Width of midbody, 23 μ.

Variations: — The length of the body, the width of the midbody, and the relative length and width of the posterior, foot-like portion of the antapical are rather variable.

Comparisons: — The description given above is based on the type material.

The specimen figured by Okamura (1907, pl. 3, fig. 15) under the name of *Amphisolenia bidentata* and in the present paper referred to *A. lemmermanni* differs from the type specimen of the last species as drawn by Kofoid (1907a) in the narrowness of its midbody but agrees closely with a number of specimens of this species found in the material of the Expedition.

The closest relative of *Amphisolenia lemmermanni* undoubtedly is *A. bidentata.* For a discussion of the relationship of these two forms, see *A. bidentata,* the section on comparisons (p. 412).

Synonymy: — The species was established by Kofoid (1907a) under the name of *Amphisolenia lemmermanni.* Okamura (1907) figured one specimen under the name of *A. bidentata* (see the last species, the section on synonymy, p. 414).

Occurrence: — *Amphisolenia lemmermanni* is recorded at twenty-six of the 127 stations. There are 5, 1, 1, 5, 11, and 3 stations on the six lines of the Expedition. Of these twenty-six stations, four (4587, 4590, 4594, 4605) are in the Mexican Current; one (4623) is in the Panamic Area; one (4667) is in the Peruvian Current; three (4691, 4697, 4699) are in the Easter Island Eddy; sixteen (4701, 4705, 4709, 4717, 4719, 4720, 4722, 4723, 4724, 4728, 4730, 4732, 4734, 4737, 4740, 4741) are in the South Equatorial Drift; one (4742) is in the South Equatorial

Current. At four of these stations (4623, 4720, 4723 [Salpa stomach], 4741) the species was found in surface catches only; at three stations (4717, 4724, 4728) in catches from both 800–0 fathoms and 300–0 fathoms. All the remaining records refer to catches from 300–0 fathoms only.

The temperature range of these twenty-six stations at the surface was 68°–85°; the average was 77.4°. At the four stations in the surface catches of which

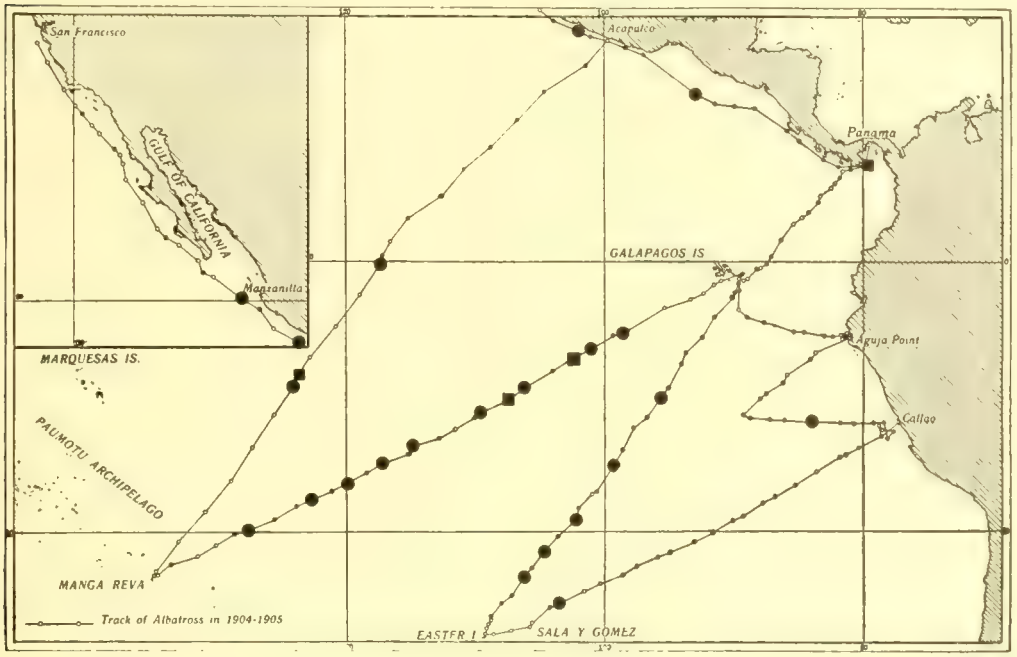

FIGURE 57.— Occurrence of *Amphisolenia lemmermanni* Kofoid. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

the species was found, the surface temperature ranged from 76° to 80°; the average was 77.7°.

The frequency is 2% at one station (4590), 1% at three stations (4691, 4717, 4719), and less than 1% at the remaining stations.

The species was first recorded by Kofoid (1907a) from Station 4730 of the Expedition, which thus is the type locality. It was found by Okamura (1907) in Japanese waters.

According to the records of the Expedition, the eupelagic habitat, the absence from the California Current, the rare occurrence in the Peruvian Current and in the part of the South Equatorial Drift that is directly influenced by this current, and the relatively frequent occurrence in the Easter Island Eddy and in the South

Equatorial Drift are the most outstanding characteristics of the distribution of this species in the Eastern Pacific. Contrary to its close relative *Amphisolenia bidentata*, it was very rare in the surface catches of the Expedition.

Amphisolenia palmata Stein

Plate 12, fig. 4, 7. Figure 54: 5, 56: 3

Amphisolenia palmata Stein, 1883, p. 24, pl. 21, fig. 11–15. Bütschli, 1885, pl. 55, fig. 4b. Schütt, 1893, p. 299. Delage & Hérouard, 1896, fig. 672. Cleve, 1897a, p. 25, tab. 1; 1900b, p. 1030; 1901a, p. 13; 1901c, p. 205; 1902b, p. 24; 1903b, p. 339. Lemmermann, 1899a, p. 316, 317, 319, 320, 331, 332, 373; 1901a, p. 376; 1904, p. 611, 643; 1905a, p. 37; 1908b, p. 127, 129. Murray & Whitting, 1899, p. 331, tab. 6, 8, 9. Schröder, 1900a, p. 20; 1906a, p. 326, 371; 1911, p. 3, 4, 25, 38. Karsten, 1906, p. 183, 184, 187, 188, 189, 190, 195, 200, 201, 206; 1907, p. 244, 248, 254, 257, 258, 260, 262, 272, 273, 275, 278, 279, 281, 282, 286, 296, 298, 305, 317, 318, 320, 324, 331, 332, 335, 336, 337, 339, 341, 342, 343, 350, 352, 353, 356, 357, 358, 471. Kofoid, 1907b, p. 315. Stüwe, 1909, p. 235, 238, 240, 254, 288. Schiller, 1911a, p. 52; 1912, p. 27. Hensen, 1895, p. 190; 1911, p. 159, 160, 161, tab. 13. Ostenfeld, 1915, p. 4. Pavillard, 1916, p. 61. Forti, 1922, p. 113. Jörgensen, 1923, p. 40, 41, fig. 57.

Amphisolenia bidentata Pavillard, 1916, *partim*, p. 61.

Diagnosis: — Slightly or moderately sigmoid. Head 1.7–2.5 times wider than long. Epitheca gently convex or flat. Midbody fusiform, merging very gradually into anterior process and antapical. Approximate distance from flagellar pore to antapical, 3.3–5.0 times longer than neck. Ratio between length and width of body, 27–42: 1. Antapical approximately 6.5–9.8 the length of neck; almost straight or with gentle ventral concavity; its posterior part bent to the right 20°–40° with or without ventral torsion of 90°. Posterior part of antapical as in *Amphisolenia bidentata* but right valve has strong, short, pointed spinule on antapex. Length, 565–810 μ.

Of world-wide distribution in tropical, subtropical, and warm-temperate regions.

Description: — The longitudinal axis of the body is slightly or moderately sigmoid, with the neck somewhat deflected dorsally, and the antapical having a slight or moderate ventral concavity. The posterior part of the antapical is always bent to the right and sometimes twisted ventrally.

The head is inclined anteriorly at an angle of 30°–45°; its axial length is 0.17 (0.11–0.26) the length of the neck; and it is 1.7–2.5 times wider than long. The anterior face of the epitheca is gently convex or more or less flattened. The transverse furrow is 0.25–0.30 as wide as the dorsoventral diameter of the head, gently convex, flat, or slightly concave and has, on each valve, about three to five cross-ridges. The cingular lists are 1.3–2.0 as wide as the transverse furrow; the anterior is generally inclined anteriorly at an angle of 10°–25°, but in the type specimen it flares at an angle of about 40°; the posterior is generally somewhat less

inclined than the anterior, sometimes even subhorizontal; each list has, on each valve, five to ten simple, equidistant ribs.

The neck is of moderate length and width, 0.06–0.09 the length of the body and eight to fourteen times longer than wide. The sulcal lists end at or somewhat behind the flagellar pore and lack ribs; the fission rib has not been observed.

The midbody is fusiform and merges very gradually into the anterior process and into the antapical. The approximate distance between the flagellar pore and the anterior end of the antapical is 3.3–5.0 times longer than the neck. The midbody is very slender, widest at a distance from the apex equaling one third to one fourth of the length of the body, or at a distance from the flagellar pore 1.5–2.5 times longer than the neck; its greatest width is 0.38 (0.25–0.56) the length of the neck. The ratio between the length and the greatest width of the body is 35 (27–42): 1.

The antapical is unbranched, approximately 6.5–9.8 the length of the neck and 1.5–2.3 times the total length of the anterior process and the midbody. It is slightly or moderately concave ventrally, and its posterior part is bent to the right at an angle of 20°–40° and sometimes twisted ventrally 90°, sometimes without torsion. Sometimes, when the antapical is characterized by a moderate ventral concavity and the posterior part of the antapical by torsion, the bending of the posterior part and the ventral concavity are confluent (Figure 56: 3). At the point of bending the left valve has a short, strong, pointed, heel-like spinule, which gives to the posterior part of the antapical a foot-like appearance. In lateral view (torsion) the foot-like part is not as wide as or is rather slightly wider than the average width of the antapical, about 2.5–4.0 times longer than wide and, if the spinules are disregarded, more or less rounded distally. Seen ventrally (torsion) the posterior part of the "foot" is truncate and about two to three times wider than the antapical just in front of the foot. The antapex has three short, strong, and pointed spinules, one on each corner and one in the middle; of these spinules the former belong to the left valve (as in *Amphisolenia bidentata*), the latter belongs to the right valve. The average width of the antapical is subequal to or somewhat exceeds that of the neck. No protoplasmic sheath of the kind found in *A. bidentata* and *A. lemmermanni* has been seen in this species.

Figure 54: 5 represents the posterior part of the antapical following binary fission; the left valve is new. It shows that the antapical spinules are not subject to resorption in fission. The spinule of the right valve is of normal size and shape, while of the three spinules of the left valve one, the heel-spinule, is not at all developed, and the others are very small.

The thecal wall has the same structure as in *Amphisolenia bidentata*.

The chromatophores are rod-shaped.

The proportions of two of our specimens and of the type specimen (Stein, 1883, pl. 21, fig. 11) and of the specimen drawn by Jörgensen (1923, fig. 57) were measured.

Dimensions: — Our specimens: Length of body, 565–661 μ. Length of head, 7–9 μ. Length of neck, 46–49 μ. Length of anterior process and midbody, 192–207 μ. Length of antapical, 301–403 μ. Width of midbody, 16–19 μ. Type specimen (Stein, 1883, pl. 21, fig. 11): Length of body, 810 μ. Length of head, 9 μ. Length of neck, 74 μ. Length of anterior process and midbody, 244 μ. Length of antapical, 486 μ. Width of midbody, 19 μ. Jörgensen's (1923, fig. 57) specimen: Length of body, 750 μ. Length of head, 11 μ. Length of neck, 47 μ. Length of anterior process and midbody, 230 μ. Length of antapical, 455 μ. Width of midbody, 28 μ.

Variations: — Judging by the few specimens that have been examined, the species appears to be rather constant. Variations occur in the length and the width of the body, the shape of the longitudinal axis of the body, and the amount of torsion in the posterior part of the antapical.

Comparisons: — The specimens found in the material of the Expedition and assigned to *Amphisolenia palmata* are comparatively small and their anterior cingular list has a rather slight anterior inclination, but in other respects they agree closely with the type specimen of this species as drawn by Stein (1883).

The specimen figured by Jörgensen (1923, fig. 57) under the name of *Amphisolenia palmata* also agrees closely with the type specimen.

Amphisolenia palmata is undoubtedly very closely related to *A. bidentata* and *A. lemmermanni*, from which it differs in having three, instead of two, spinules on the antapex, in other words, in having an antapical spinule on the right valve. Other close relatives of *A. palmata* are *A. palaeotheroides*, characterized by its very short and thick antapical, and *A. asymmetrica*, characterized by its excessively wide head. With regard to Kofoid's (1907b, p. 315) suggestion that *A. palmata* and *A. spinulosa* are closely related, see the section on the subdivision of the genus (p. 360). For further discussion of the relationships between the species of the PALMATA group, see the section on the comparisons of *Amphisolenia bidentata* (p. 412).

Synonymy: — The species was established by Stein (1883) under the name of *Amphisolenia palmata*. Of later investigators only Jörgensen (1923) gives drawings by means of which the determinations may be checked. Bütschli (1885) and

Delage and Hérouard (1896) give reproductions of Stein's (1883) figures of the type specimen.

With regard to Cleve's determinations of this species, see Schröder (1906a, p. 371) and Ostenfeld (1915, p. 4). Since no data bearing upon this question have been published as yet, Cleve's determinations have been accepted in this paper.

Concerning one specimen recorded by Pavillard (1916) from the Gulf of Lyons under the name of *Amphisolenia bidentata* and referred to *A. palmata* in the present paper, see the section on the synonymy of *A. bidentata* (p. 414).

Jörgensen (1923, p. 40) writes that *Amphisolenia palmata* "has been confused with and included under *A. bidentata*"; however, no data are given in support of this statement.

Occurrence: — *Amphisolenia palmata* is recorded at six of the 127 stations. There are 1, 0, 1, 2, 2, and 0 stations on the six lines of the Expedition. Of these six stations, one (4587) is in the Mexican Current; two (4697, 4700) are in the Easter Island Eddy; three (4688, 4734, 4737) are in the South Equatorial Drift. At two of these six stations (4688, 4700) the species was found in surface catches only; at the remaining stations in catches from 300–0 fathoms only.

The temperature range of these six stations at the surface was 72°–82°; the average was 77.6°. At the two surface Stations 4689, 4700, the temperatures at the surface were 72° and 74°, respectively.

The frequency is less than 1% except at Station 4688, where it is 1%.

The species was first recorded by Stein (1883) "aus der Südsee"; the type locality is unknown. In the Atlantic Ocean it was found by Schütt (1893), who mentioned it as characteristic of the Florida Current and of the Sargasso Sea; by Cleve (1897a) at lat. 37° 47′ N., long. 47° 31′ W., and at lat. 35° 57′ N. and long. 58° 3′ W., *i.e.*, in the Sargasso Sea; by Lemmermann (1899a) at three stations, viz., lat. 3° N., long. 27° W., lat. 14° S., long. 27° W., and lat. 21° S., long. 26° W.; by Murray and Whitting (1899) at twenty-one stations, from near the east coast of America, including the Caribbean Sea, to near the west coast of Europe and of Africa, and from lat. 38° N. to lat. 14° N.; by Cleve (1901c) at a fairly great number of stations, from near the east coast of America, including the Caribbean Sea, to near the west coast of Europe and of Africa, and from lat. 42° N. to lat. 19° S.; by Cleve (1902b) at five stations, four of which are in the region of distribution established by Cleve (1901c) and one as far south as lat. 21° S., long. 1° E.; by Stüwe (1909) at fifteen stations in the eastern part of the Atlantic, between lat. 34° N. and lat. 3° N.; and by Karsten (1906) at ten stations along the west coast of Africa, between lat. 12° N. and lat 5° S.; by Hensen (1911) at a very great num-

ber of stations in different parts of the tropical, subtropical and warm-temperate regions of the Atlantic. Jörgensen (1923, p. 40) states that the Atlantic distribution of *Amphisolenia palmata* is unknown, as this species "has been confused with and included under *A. bidentata*." This statement is very plausible but not supported by any published records. In this absence, the data given above are treated as valid. Jörgensen (1923) found *A. palmata* at seven stations in different parts of the Mediterranean; Cleve (1903b) at lat. 37° N., long. 0°–12° E.; Pavillard (1916) in the Gulf of Lyons; Schröder (1911) and Schiller (1911a, 1912) in the Adriatic Sea. In the Red Sea it was found by Cleve (1900b, 1903b) and by Karsten (1907); in the Gulf of Aden by Cleve (1903b) and by Karsten (1907); in the Arabian Sea by Cleve (1901a, 1903b) and Schröder (1906a); in the Indian Ocean by Cleve (1901a) and by Karsten (1907). Karsten (1907) recorded the species from thirty-one of the stations of the Valdivia Expedition; of these stations twenty-seven are in the Indian Ocean, from near the west coast of Sumatra to near the east coast of Africa, and between lat. 8° N. and lat. 12° S. In the Malay Archipelago it was found by Cleve (1901a); in the mouth of the river Menam by Lemmermann (1908b), probably dead, the cytoplasm disintegrating, certainly carried in by the tidal water. Lemmermann (1899a, 1904) recorded it from four localities in the Pacific, viz., at lat. 6° N., long. 111° W., lat. 12° N., long. 117° W., Pearl Harbor in the Island of Oahu, and between Laysan and Hawaii.

Most of the records referred to above were from surface catches. No certain closing-net records are available (see Karsten, 1907, p. 258).

The species occurs in waters of the following temperatures and salinities: — Murray and Whitting (1899): temperature range, 60°–81°. Cleve (1901a): temperature range, 80.2°–82.9°; salinity range, 33.06–33.71. Cleve (1901c): temperature range, 61.5°–82.7°; mean of sixty-five observations, 76.0°. Salinity: range, 33.20–37.37; mean of thirty-four observations, 36.22. Cleve (1902b): temperature, mean of ten observations, 72.3°; salinity, mean of ten observations, 36.61. Cleve (1903b): temperature range, 57.0°–88.4°; mean of twelve observations, 78.4°. Salinity: range, 36.02–39.92; mean of twelve observations, 37.38. Stüwe (1909): temperature range, 65.0°–82.8°.

Of the writers who have contributed to our knowledge of the distribution of this species only Stein (1883) and Jörgensen (1923) give drawings by means of which the accuracy of their determinations may be judged (see the section on the synonymy of this species, p. 424).

The species is eupelagic and widely distributed in tropical, subtropical, and

warm-temperate seas. While it has been recorded a rather great number of times from other seas (Hensen, 1911, found it to be by far the most frequent species of this genus), it appears to be rare in the region investigated by the Expedition. In the Eastern Pacific it occurs in waters of high average temperature (77.6°). Its absence from the relatively cool Peruvian Current and its relatively frequent occurrence in the Easter Island Eddy, according to our records, are noteworthy.

Amphisolenia palaeotheroides Kofoid

Plate 11, fig. 2, 3, 4. Figure 56: 4

Amphisolenia palaeotheroides Kofoid, 1907a, p. 199, pl. 14, fig. 84.

Diagnosis:—Almost straight. Head 1.5–2.0 times wider than long. Epitheca gently convex. Midbody fusiform and passes imperceptibly into anterior process and antapical. Approximate distance from flagellar pore to antapical about seven times longer than neck. Ratio between length and width of body, 21–51: 1. Antapical approximately about twice the length of neck, straight; its posterior part bent to the right 20°–40°, without ventral torsion and of the same structure as in *Amphisolenia palmata;* its spinules very strong. Length, 426–615 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is almost straight; the neck is gently curved dorsally, and the posterior part of the antapical is bent to the right.

The head is inclined anteriorly at an angle of 20°–25°; its axial length is about 0.23 the length of the neck; and it is 1.5–2.0 times wider than long. The anterior face of the epitheca is gently convex. The transverse furrow is about 0.28 as wide as the dorsoventral diameter of the head, flat or slightly concave and has, on each valve, four to six cross-ridges. The cingular lists are 1.3–2.0 times wider than the transverse furrow; the anterior is inclined anteriorly at an angle of 15°–25°, the posterior has the same inclination or is subhorizontal; each list has, on each valve, six to eight simple, equidistant ribs.

The neck is of moderate length and width, about 0.10 the length of the body and seven to ten times longer than wide. The two sulcal lists end at the flagellar pore, or the left list continues a short distance behind the pore; they either lack ribs, or the left has a fission rib at the flagellar pore.

The midbody is fusiform and passes imperceptibly into the anterior process and into the antapical; its relative length is almost impossible to determine even approximately. The approximate distance between the flagellar pore and the

anterior end of the antapical appears to be about seven times longer than the neck. The midbody is very slender, widest near the middle of the body; its greatest width is 0.36–0.50 the length of the neck. The ratio between the length and the greatest width of the body is 31 (21–51): 1; the type specimen is the stoutest of all specimens seen, with a ratio of 21: 1.

The antapical is unbranched; its approximate length (see the previous paragraph) is about twice the length of the neck and 0.28 the total length of the anterior process and the midbody. Its anterior part is straight. Its posterior part is bent to the right at an angle of 20°–40° but never, as far as our experience goes, twisted ventrally; its structure is the same as in *Amphisolenia palmata;* the antapical spinules are very strong. In one specimen, characterized by a rather weak antapical spinule on the right valve, the posterior part of the antapical was characterized by what appeared to be a protoplasmic sheath.

The thecal wall has the same structure as in *Amphisolenia bidentata.*

The nucleus is large, oblong, and somewhat irregular. The chromatophores are subspheroidal, subellipsoidal, or rod-like.

The length and the width of the body were measured in five specimens, and the proportions of the head and of the neck in two specimens. All the proportions were measured in one specimen only, the type.

Dimensions: — Length of body, 426–615 μ (average, 513 μ; type, 475 μ). Length of head, 10–11 μ. Length of neck, 43–48 μ (type, 48 μ). Length of anterior process, midbody, and antapical of type, 415 μ. Width of midbody, 12.0–22.3 μ (average, 17.5 μ; type, 22.3 μ).

Variations: — Judging by the specimens that have been carefully examined, the species appears to be rather constant. The length and the width of the body are the most variable characters.

Comparisons: — The description given above is based on the type material. *Amphisolenia palaeotheroides* is undoubtedly very closely related to *A. palmata,* as is shown by the similar differentiation of the posterior portion of the antapical in these two species. It is easily distinguished from the last species by its comparatively very short and thick antapical. Other close relatives of *A. palaeotheroides* are *A. asymmetrica,* characterized by its excessively wide head, and *A. bidentata* and *A. lemmermanni,* characterized by having only two spinules on the antapex, in other words, by lacking an antapical spinule on the right valve. For further discussion of the relationships of these species, see the section on the comparisons of *Amphisolenia bidentata* (p. 412).

Occurrence: — *Amphisolenia palaeotheroides* is recorded at twelve of the 127

stations. There are 0, 1, 2, 4, 4, and 1 stations on the six lines of the Expedition. Of these twelve stations, one (4668) is in the Peruvian Current; three (4689, 4691, 4699) are in the Easter Island Eddy; eight (4701, 4707, 4709, 4728, 4732, 4734, 4737, 4740) are in the South Equatorial Drift. At one station (4732) the species is recorded from 800–0 fathoms; at one station (4701) from 800–0 fathoms as well as from 300–0 fathoms. All the remaining records refer to catches from 300–0 fathoms only.

The temperature range of these twelve stations at the surface was 67.0°–81.5°; the average was 75.2°.

The frequency is less than 1% except at three stations (4689, 4699, 4737) where it is 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4732 of the Expedition, which thus is the type locality.

Although the species was found at as many as twelve of the stations of the Expedition, it has been recorded only once outside the Easter Island Eddy and the South Equatorial Drift.

Amphisolenia asymmetrica Kofoid

Plate 11, fig. 5, 6, 7, 13. Figure 54:6, 56:5

Amphisolenia asymmetrica Kofoid, 1907a, p. 196, pl. 13, fig. 76.
Amphisolenia dolichocephalica Kofoid, 1907a, p. 196, pl. 13, fig. 82. Doflein, 1909, p. 464, fig. 403c; 1911, p. 531, fig. 462c; 1916, p. 437, fig. 374c.

Diagnosis: — Gently sigmoid. Head nine to ten times wider than long. Epitheca flat. Midbody fusiform, merging almost gradually into anterior process and midbody. Distance from flagellar pore to antapical, 4.0–6.5 times longer than neck. Ratio between length and width of body, 44–55: 1. Antapical 11.5–14.5 the length of neck, with gentle ventral concavity; its posterior, foot-like part of about the same structure as in *Amphisolenia palmata* but seven to eight times longer than wide. Length, 1080–1207 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is gently sigmoid, with the neck slightly deflected dorsally and the antapical having a gentle ventral concavity. The posterior part of the antapical is bent to the right and sometimes twisted ventrally.

The head is inclined anteriorly at an angle of 20°–30°; its axial length is 0.13–0.14 the length of the neck; and it is nine to ten times wider than long; its

width even somewhat exceeds the length of the neck. The anterior face of the epitheca is flat. The transverse furrow is 0.06 as wide as the dorsoventral diameter of the head, gently convex or flat, and without cross-ridges. The cingular lists are about 1.3–1.8 as wide as the transverse furrow, subhorizontal, and furnished with a great number, about 25–30 on each valve, of simple, equidistant ribs.

The neck is rather short, 0.05–0.06 the length of the body, and 11 times longer than wide. The sulcal lists end at the flagellar pore and have no ribs.

The midbody is fusiform and merges almost gradually into the anterior process and into the antapical. The distance between the flagellar pore and the anterior end of the antapical is 5.0 (4.0–6.5) times longer than the neck. The midbody is very slender, widest at a distance from the apex equaling about one fourth of the length of the body, or at a distance from the flagellar pore 2.5–3.5 times longer than the neck; its greatest width is 0.30–0.50 the length of the neck. The ratio between the length and the greatest width of the body is 50 (44–55) : 1.

The antapical is unbranched, 12.8 (11.5–14.5) the length of the neck and two to three times the total length of the anterior process and the midbody. It is gently concave ventrally, and its posterior part is bent to the right at an angle of 20°–40° and sometimes twisted ventrally 90°, sometimes without torsion. Sometimes, when the antapical is characterized by torsion, the bending of the posterior part and the ventral concavity are confluent. The posterior foot-like part of the antapical has about the same structure as in *Amphisolenia palmata*, but is seven to eight times longer than wide. The antapical spinules are of moderate strength. The average width of the antapical is subequal to or somewhat exceeds that of the neck. In one specimen the posterior part of the antapical was characterized by what appeared to be a protoplasmic sheath (see below, the section on the synonymy).

The thecal wall is apparently without structure. Near the antapex there is, on each valve, a longitudinal row of fine pores and a few scattered pores. On the neck no pores were observed but these may have been overlooked.

The proportions of three specimens were measured; among these specimens were the types of this species and of *Amphisolenia dolichocephalica*.

Dimensions: — Length of body, 1080–1207 μ (type, 1207 μ). Length of head, 8 μ. Length of neck, 58–62 μ (type, 58 μ). Length of anterior process and midbody, 274–348 μ (type, 348 μ). Length of antapical, 722–765 μ (type, 765 μ). Width of midbody, 20–28 μ (type, 28 μ).

Variations: — The species appears to be rather constant. Variations occur in the length and the width of the body and in the relative length of the midbody.

Comparisons: — The description given above is based on the type material. It should be mentioned in this connection that, unfortunately, an error has crept into the preliminary description of this species given by Kofoid (1907a, p. 196). We read as follows: — "Walls thickened distally along sutures which do not follow the median plane of symmetry through the apparently twisted antapex but divide it into two asymmetrical valves, the right with two terminal spinules and the left with one terminal and the lateral." As we have seen from the description given above, the right valve has only one antapical spinule, the middle one of the three spinules on the antapex; and the left valve has three spinules, the two outer ones of the three spinules on the antapex and the heel-spinule (the "lateral" spinule).

Amphisolenia asymmetrica undoubtedly is rather closely related to *A. palmata*, *A. palaeotheroides*, *A. bidentata*, and *A. lemmermanni*. It is easily distinguished from these species by the great length of its body, the excessive width of its head, and the great relative length of the posterior foot-like part of its antapical. For further discussion of the relationships of these species, see the section on the comparisons of *Amphisolenia bidentata* (p. 412).

Synonymy: — The species was established by Kofoid (1907a) under the name of *Amphisolenia asymmetrica*.

In the same paper Kofoid (1907a, p. 198) described another species of this genus, *Amphisolenia dolichocephalica*, which, according to the original description and drawing, differs from *A. asymmetrica* mainly in the following respects: — (*1*) the posterior, foot-like part of its antapical has no "heel-spinule," only two spinules on the antapex, and "decurrent hyaline ridges which pass quickly from the knob-like end to the slender cylindrical stem"; (*2*) its midbody is somewhat narrower; (*3*) its size is somewhat smaller. These two species probably are identical for the following reasons: — (*1*) The specimen on which *A. dolichocephalica* was founded had been taken just following binary fission; its left (new) valve was but slightly differentiated (see Plate 11, fig. 6, showing the slight development of the cingular lists of the left valve). The posterior, foot-like part of the antapical had the same number and arrangement of spinules as in Figure 54:5 of *A. palmata* (Figure 54:6). The absence of a "heel-spinule" and the slight development of the two spinules on the antapex of the left valve should be interpreted as an early stage following binary fission and not as being due to genetic causes. The "hyaline ridges" of *A. dolichocephalica* certainly correspond to what we have interpreted as a "hyaline sheath" in *A. bidentata*, *A. lemmermanni*, and *A. globifera*. The material of this sheath is possibly utilized in thickening the

thecal walls of "the foot." The absence of a sheath would be a sign of more advanced age. The thickness of the thecal wall near the antapex in *A. asymmetrica* may be noteworthy in this connection (Plate 11, fig. 5). However, it must be emphasized that we have no conclusive proofs in support of this interpretation. (*2*) The narrowness of the midbody in *A. dolichocephalica* is probably also a sign of recent binary fission. (*3*) The difference in size is not greater than in related species.

Doflein (1909, 1911, 1916) used the name *Amphisolenia dolichocephalica* for this species and gives a reproduction of Kofoid's (1907a) Plate 13, figure 82.

Occurrence: — *Amphisolenia asymmetrica* is recorded at three of the 127 stations of the Expedition. These three stations (4728, 4732, 4739) are on the fifth line of the Expedition and in the South Equatorial Drift. At one station (4732) the species was found in a catch from 800–0 fathoms as well as in a catch from 300–0 fathoms; at the two other stations in catches from 300–0 fathoms only.

The temperature range of these three stations at the surface was 77°–79°; the average was 78.3°.

The frequency is less than 1% except at Station 4732, where it is 1%.

The species has been found only in the material of the Expedition. It previously has been recorded from Stations 4728 and 4732 of the Expedition. Station 4732 is the type locality. The restriction of the records of this species to the South Equatorial Drift is noteworthy.

7. Bifurcata Group. All the five species that belong to this group have been found in the material of the Expedition. They have been treated in this paper in the following order indicative of relationships: — *Amphisolenia bifurcata*, *A. projecta*, *A. thrinax*, *A. quadricauda*, and *A. quinquecauda*.

Amphisolenia bifurcata Murray and Whitting

Plate 12, fig. 1, 3, 5. Figure 56: 6

Amphisolenia bifurcata Murray & Whitting, 1899, p. 331, tab. 7, 8, 9, pl. 31, fig. 1a–e. Lemmermann, 1899a, p. 373; 1901a, p. 376. Schröder, 1900a, p. 20. Cleve, 1902b, p. 24. Kofoid, 1906c, p. 94, 95; 1907a, p. 199. Karsten, 1907, p. 243, 425, 472. Stüwe, 1909, p. 236, 242, 254, 288.
Amphisolenia thrinax Zacharias, 1906, p. 561, 563, 564.

Diagnosis: — Almost straight or gently sigmoid in front of bifurcation. Head three to four times wider than long. Epitheca flat or gently convex. Midbody fusiform merging gradually into anterior process and antapical. Distance from flagellar pore to antapical, 3.7–4.3 times longer than neck. Ratio between length and width of body, 19–26:1. Antapical bifurcate; stem in front of bifur-

cation straight or slightly concave ventrally and 6.0–9.7 the length of neck. Antapical limbs subequal or somewhat different in length, the dorsal 2.6–5.3, the ventral 2.6–4.5 times longer than neck; their proximal or middle portions somewhat inflated, fusiform, 1.5–2.5 the average width of the antapical stem in front of bifurcation; their distal portions with spinules of the *palmata* type. Length 794–1050 μ.

Of world-wide distribution in tropical and subtropical waters.

Description: — The longitudinal axis of the body is almost straight or gently sigmoid in front of the bifurcation; in some specimens the neck is somewhat deflected dorsally; and the undivided antapical stem is straight or gently concave ventrally. The antapical limbs have a spread of 15°–25°.

The head is inclined anteriorly at an angle of 20°–30°; its axial length is 0.18–0.25 the length of the neck; and it is three to four times wider than long. The anterior face of the epitheca is flat or gently convex. The transverse furrow is about 0.18 as wide as the dorsoventral diameter of the head, flat or gently convex and has, on each valve, about six to nine cross-ridges. The cingular lists are 1.5–2.0 times as wide as the transverse furrow; the anterior flares anteriorly at an angle of 15°–20° and has, on each valve, about nine to eleven simple, equidistant ribs; the posterior is subhorizontal and has, as a rule, a somewhat smaller number of ribs.

The neck is rather short, 0.05–0.06 the length of the body, and five to seven times longer than wide. The sulcal lists end at the flagellar pore and have no ribs.

The midbody is fusiform and merges gradually into the anterior process and into the antapical. The distance between the flagellar pore and the anterior end of the antapical is 4.0 (3.7–4.3) times longer than the neck. The midbody is of moderate width or more or less slender, widest at a distance from the apex equaling about one fourth to one fifth of the length of the body, or at a distance from the flagellar pore 2.0–2.5 the length of the neck; its greatest width is 0.6–1.0 the length of the neck. The ratio between the length and the greatest width of the body is 22 (19–26) : 1.

The antapical is bifurcate. The antapical stem in front of the bifurcation is straight or slightly concave ventrally, 6.0–9.7 the length of the neck and 1.6–2.3 times the total length of the anterior process and the midbody; it is of about the same width throughout its whole length, and its width is subequal to or somewhat exceeds that of the neck. The two antapical limbs, one of which is the originally posterior part of the antapical, are either subequal or of somewhat different lengths; when they are of different lengths, the dorsal appears always to be the longer; the dorsal is 2.6–5.3, the ventral 2.6–4.5 the length of the neck. In

the type specimen (Murray and Whitting, 1899, pl. 31, fig. 1a) the ratio between the length of the dorsal limb and the length of the ventral limb was about 5: 4; in our specimens the difference in length always was less; in the type specimen the dorsal limb was but slightly shorter than the antapical stem in front of the bifurcation; in our specimens the corresponding ratio is 0.36–0.37: 1. The proximal or the middle portion of each limb is somewhat inflated, fusiform, 1.5–2.5 the average width of the antapical stem in front of the bifurcation. The posterior end of each limb is rather narrow and has fairly weak or moderately strong spinules of the *palmata* type.

The thecal wall has rather widely spaced minute pores, partly arranged in more or less regular, longitudinal rows.

The nucleus is fairly large, ellipsoidal. The chromatophores are spheroidal or ellipsoidal and of various sizes.

The proportions of three of our specimens and of the type specimen were measured.

Dimensions: — Our specimens: Length of body, 865–896 μ (average, 871 μ). Length of head, 9–10 μ. Length of neck, 45–55 μ (average, 51 μ). Length of anterior process and midbody, 181–210 μ (average, 201 μ). Width of midbody 39–46 μ (average, 43 μ). Length of antapical stem in front of bifurcation, 444–461 μ (average, 450 μ). Length of inside of ventral limb, 122–136 μ (average, 131 μ). Length of inside of dorsal limb, 136–145 μ (average, 138 μ). Type specimen (Murray and Whitting, 1899, pl. 31, fig. 1a): Length of body, 794 μ. Length of head, 9 μ. Length of neck, 50 μ. Length of anterior process and midbody, 181 μ. Width of midbody, 30 μ. Length of antapical stem in front of bifurcation, 297 μ. Length of inside of ventral limb, 204 μ. Length of inside of dorsal limb, 250 μ. Zacharias's (1906, p. 563, 564) specimen: Length of body, 1050 μ. Length of "Proabdomen" (= neck and anterior process), 112 μ. Length of "abdominal Spindel" (= midbody), 160 μ. Length of "Postabdomen" (= antapical stem), 458 μ. Length of "zinkenähnliche Fortsätze" (= antapical limbs), 320 μ.

Variations: — The specimens examined by us were very constant. The most variable characters in this species, as conceived in the present paper, are the width of the midbody, the relative length of the antapical stem in front of the bifurcation, and the relative length and width of the antapical limbs.

Comparisons: — The specimens found in the material of the Expedition and referred to *Amphisolenia bifurcata* differ from the type specimen of this species as described and figured by Murray and Whitting (1899) in having the antapical stem in front of the bifurcation comparatively longer and the antapical limbs

comparatively shorter. In spite of these differences the assignment of our specimens may be regarded as fairly certain.

The species undoubtedly is closely related to *Amphisolenia thrinax*, *A. quadricauda*, and *A. quinquecauda*. The great structural resemblance between the antapical limbs in these four species can hardly be explained except by the assumption of close relationship. The main differentiating character is the number of the antapical limbs.

With regard to the relationship between *Amphisolenia bifurcata* and *A. projecta*, see *A. projecta* (p. 438).

Amphisolenia bifurcata, *A. projecta*, *A. thrinax*, *A. quadricauda*, and *A. quinquecauda* form a natural systematic unit, the BIFURCATA group, which in many respects is the most highly differentiated group in the genus. Their closest relatives, outside the group, are probably to be found in the PALMATA group.

Synonymy: — The species was established by Murray and Whitting (1899) under the name of *Amphisolenia bifurcata*. This name has been used by later writers, but none of them has given any drawings by means of which the determinations may be checked.

Amphisolenia thrinax Zacharias (1906) is probably a synonym of *A. bifurcata*. All the statements made by Zacharias (1906, p. 563, 564) about the specimen that he referred to *A. thrinax* agree with our conception of *A. bifurcata*. The author accounted for the fact that his specimen had only two antapical limbs by assuming that these limbs varied in number in *A. thrinax*.

Occurrence: — *Amphisolenia bifurcata* is recorded at six of the 127 stations. There are 1, 0, 1, 3, 1, and 0 stations on the six lines of the Expedition. Of these six stations, one (4583) is in the California Current; three (4691, 4695, 4699) are in the Easter Island Eddy; two (4701, 4724) are in the South Equatorial Drift. All the records refer to catches from 300–0 fathoms.

The temperature range of these six stations at the surface was 72°–83°; the average was 76.0°. The frequency is less than 1%.

The species was first recorded by Murray and Whitting (1899) from four localities in the tropical and subtropical regions of the Atlantic Ocean and in the Caribbean Sea, viz., lat. 29°–31° N., long. 44°–42° W., lat. 16°–17° N., long. 69°–72° W., lat. 14°–15° N., long. 63°–67° W., and lat. 4°–6° S., long. 32°–33° W. No information is given as to which of these four stations is the type locality. Zacharias (1906) recorded it, under the name of *Amphisolenia thrinax*, from lat. 14° N., long. 41° W.; Stüwe (1909) from lat. 3° N., long. 26° W. Cleve (1902b) found it somewhat farther south in the Atlantic than previous authors, viz., at lat. 24° S.,

long. 41° W. Karsten (1907) reported it as taken in the Indian Ocean, at one of the stations of the Valdivia Expedition, lat. 18° S., long. 96° E. Most of the records referred to above were from catches made at or near the surface; Stüwe's (1909) were from 150 (100)–0 m.

The species occurs in waters of the following temperatures and salinities: — Murray and Whitting (1899): temperature range, 67°–81°; average of four observations, 76.5°. Cleve (1902b): temperature, 73°; salinity, 37.07. Stüwe (1909): temperature, 80.2°.

Of the writers who have contributed to our knowledge of the distribution of this species only Murray and Whitting (1899) give drawings by means of which their determinations may be verified.

The species probably is eupelagic and has a world-wide distribution in tropical and subtropical seas, but it is very rare. With regard to its occurrence in the Eastern Pacific, according to our records, its absence from the relatively cool Peruvian Current is most noteworthy.

Amphisolenia projecta Kofoid

Figure 56: 7, 58

Amphisolenia projecta Kofoid, 1907a, p. 199, pl. 13, fig. 77.

Diagnosis: — Almost straight in front of bifurcation. Midbody fusiform, merging gradually into anterior process and antapical. Distance from flagellar pore to antapical, 2.4 times longer than neck. Ratio between length and width of body, 18–19: 1. Antapical bifurcate; stem in front of bifurcation straight and 3.7 the length of neck. Antapical limbs very unequal; the ventral 1.8 the length of neck, its proximal half inflated, fusiform, about twice as wide as antapical stem in front of bifurcation, its distal portion with spinules of the *palmata* type; the dorsal limb about 0.33 the length of ventral, of about the same shape as proximal portion of ventral, obliquely truncate posteriorly, without spinules. Length, 185 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body is almost straight in front of the bifurcation. The antapical limbs have a spread of 30°.

The shape and the inclination of the head are not known with certainty. Probably the head is inclined anteriorly at an angle of about 20°; its axial length is probably 0.17–0.25 the length of the neck; and it is probably about three times wider than long. The anterior face of the epitheca is probably flat or gently convex. The cingular lists are probably about 1.5–2.0 times as wide as the trans-

verse furrow; the anterior flares anteriorly at an angle of about 20°, the posterior is subhorizontal.

The neck is of moderate length, 0.11 the length of the body, and seven to nine times longer than wide.

The midbody is fusiform and merges gradually into the anterior process and into the antapical; its ventral margin is less convex than the dorsal. The distance between the flagellar pore and the anterior end of the antapical is about 2.4 times longer than the neck. The midbody is of moderate width, widest at a distance from the apex equaling about one third to one fourth the length of the body, or at a distance from the flagellar pore about 1.5 the length of the neck; its greatest width is 0.55 the length of the neck. The ratio between the length and the greatest width of the body is 18–19: 1.

The antapical is bifurcate. The antapical stem in front of the bifurcation is straight, 3.7 the length of the neck and 1.4–1.6 times the total length of the anterior process and the midbody; it is of about the same width throughout its whole length, and its width is subequal to or somewhat exceeds that of the neck. The antapical limbs are very unequal. The ventral is 1.8 the length of the neck; its proximal half is inflated and fusiform and about twice as wide as the antapical stem in front of the bifurcation; its posterior portion is slender and has moderately strong spinules of the *palmata* type. The dorsal limb is about 0.33 the length of the ventral, of about the same shape as the proximal portion of the ventral, obliquely and broadly truncate posteriorly, and lacks spinules.

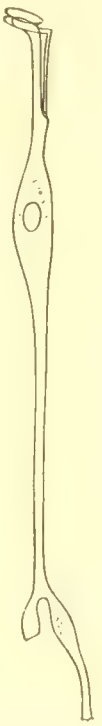

FIGURE 58.—*Amphisolenia projecta* Kofoid, right lateral view of type specimen, after free-hand sketch from life, and attached measurements and notes. ×510. Station 4701 (300–0 fathoms).

The nucleus is of moderate size, ellipsoidal, and longitudinal. The chromatophores are numerous, small, and greenish yellow; most of them are to be found in the anterior portion of the midbody and in the inflated portion of the ventral antapical limb.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 185 μ. Length of head, about 3.5 μ. Length of neck, 20 μ. Length of anterior process and midbody, 49 μ. Width of midbody, 10 μ. Length of antapical stem in front of bifurcation, 75 μ. Length of ventral antapical limb, 36 μ.

Comparisons: — Only one specimen of this species has been seen. This speci-

men was found by the senior author in his preliminary examination of the material of the Expedition when still on board the Albatross. A freehand drawing made on board ship and the attached measurements were used in making Figure 58 of the present paper. This figure and not Plate 13, figure 77, of the original description (Kofoid, 1907a) is the basis of the description given above. It should be noted that the shape and inclination of the head are uncertain; in the original sketch the head is not drawn but only the cingular lists.

The question as to whether or not this is a valid species cannot be settled as yet. The type specimen possibly may be a representative of *Amphisolenia bifurcata* in which the dorsal antapical limb is broken. This supposition, which necessitates the assumption that the length of the body (185 μ) given in the original description is wrong, is supported by the close similarity between the neck, the anterior process, the midbody, the antapical stem in front of the bifurcation, and the ventral antapical limb in *A. projecta* and the corresponding parts in *A. bifurcata*. Furthermore, the dorsal antapical limb in *A. projecta* has the same shape as the proximal part of the ventral limb; and its obliquely and broadly truncate tip, lacking spinules, suggests the possibility of a broken process. On the other hand, the fact that there is no indication of mistake in the original measurements, and the fact that closely related dwarfs and giants rather frequently have been found in this tribe make it necessary to treat *A. projecta*, tentatively, as a valid species. The type specimen of this species has been searched for in the type material but without success.

Amphisolenia projecta is undoubtedly most closely related to *A. bifurcata*. It differs from this species mainly in size (185 μ as compared to 794–1050 μ) and in the relative length and shape of the dorsal, non-spinulate, antapical limb (see *A. bifurcata*, the section on comparisons, p. 434).

Occurrence: — This species is recorded at only one of the 127 stations. This station (4701) is on the fourth line of the Expedition and in the South Equatorial Drift. The depth is 300–0 fathoms, the surface temperature 72°, and the frequency less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4701 of the Expedition, which thus is the type locality.

Amphisolenia thrinax Schütt

Plate 12, fig. 2, 6. Figure 54: 7–9, 56: 8, 59

Amphisolenia thrinax Schütt, 1893, p. 271, 299, 301, fig. 81. Lemmermann, 1899a, p. 319, 331, 373; 1901a, p. 376. Murray & Whitting, 1899, p. 331, tab. 6, 8. Schröder, 1900a, p. 20; 1906a, p. 326, 328. Ostenfeld & Schmidt, 1901, p. 163. Cleve, 1901a, p. 13; 1901c, p. 206. Kofoid, 1906c, p. 94,

95; 1907a, p. 199, 200. KARSTEN, 1907, p. 244, 249, 263, 272, 273, 280, 282, 283, 284, 286, 287, 288, 291, 295, 296, 301, 307, 308, 312, 314, 322, 345, 346, 349, 350, 425, 427, 440, 442, 472, 473. STEUER, 1910, fig. 105; 1911, fig. 81. KOFOID & MICHENER, 1911, p. 293. HENSEN, 1911, p. 159, 160, tab. 13. OKAMURA, 1912, p. 20, fig. 51a–c. OLTMANNS, 1923, p. 327, fig. 718: 2.

non *Amphisolenia thrinax* ZACHARIAS, 1906, p. 561, 563, 564.

Diagnosis: — Resembling *Amphisolenia bifurcata* but with two antapical branches. Length of antapical stem in front of the first branch variable, 2.0–7.0 the length of neck. Length, 720–1049 μ.

Of world-wide distribution in tropical, subtropical, and warm-temperate waters.

Description: — The longitudinal axis of the body is almost straight or gently sigmoid in front of the first antapical branch; the neck is, in some specimens, somewhat deflected dorsally, and the anterior portion of the antapical stem, which generally is straight, is sometimes gently concave ventrally. The portion of the antapical stem behind the first branch has a more or less pronounced and somewhat variable sigmoid curvature. The first antapical branch has a spread of 35°–50°; the spread of the second antapical branch is 25°–45°.

The head is inclined anteriorly at an angle of 20°–40°; its axial length is 0.14–0.25 the length of the neck; and it is 3.0–4.5 times wider than long. The anterior face of the epitheca is flat or gently convex. The transverse furrow is 0.16–0.20 as wide as the dorsoventral diameter of the head, somewhat convex, flat, or slightly concave and has, on each valve, six to ten cross-ridges. The cingular lists are 1.5–2.0 times as wide as the transverse furrow; the anterior flares anteriorly at an angle of 10°–20° and has, on each valve, about eight to twelve simple, equidistant ribs; the posterior is subhorizontal and has, as a rule, a somewhat smaller number of ribs.

The neck is rather short, 0.06–0.08 the length of the body, and six to eight times longer than wide. The sulcal lists extend to or somewhat behind the flagellar pore; ribs have not been seen but probably are as in *Amphisolenia quadricauda*.

The midbody is fusiform and merges gradually into the anterior process and into the antapical. The distance between the flagellar pore and the anterior end of the antapical is 3.0–4.5 times longer than the neck. The midbody is of moderate width or more or less slender, widest at a distance from the apex equaling about one fourth of the length of the body, or at a distance from the flagellar pore 1.5–2.5 the length of the neck; its greatest width is 0.6–0.9 the length of the neck. The ratio between the length and the greatest width of the body is 22 (18–26) : 1.

The antapical has two branches. The antapical stem in front of the first branch is generally straight, seldom slightly concave ventrally; in the specimens figured by Schütt (1893) and Okamura (1912) it is rather long, 5.5–7.0 times

longer than the neck and 1.7–2.0 the total length of the anterior process and the midbody; in some of our specimens (Plate 12, fig. 6) it is short, about twice as long as the neck and 0.6–0.7 the total length of the anterior process and the midbody; it is of about the same width throughout its whole length, and its width is subequal to or somewhat exceeds that of the neck. Of the two antapical branches the first is generally slightly longer and the second somewhat shorter than the portion of the antapical stem that is behind the second branch; however, the relative lengths of the branches and of the portion of the antapical stem that is behind the second branch are somewhat variable; the first branch is 1.8–4.8, the second branch 1.5–3.3, and the posterior part of the antapical stem behind the second branch 1.5–4.1 the length of the neck. Sometimes the branches and the posterior portion of the antapical stem are almost straight, sometimes gently curved or of a sigmoid shape; these differences may, however, to some extent be apparent, due to differences in the positions of the organism. The two branches are frequently of an almost uniform thickness, about as wide as the anterior portion of the antapical stem; the proximal and the middle parts of the portion of the antapical stem behind the second branch, on the other hand, are generally more or less swollen, sometimes even about three times wider than the anterior portion of the antapical stem. In one of the specimens figured by Okamura (1912, fig. 51c) the antapical stem is strikingly widened at the base of the second branch, about three times wider than the anterior portion of the antapical stem. The distal part of both the first branch and the main antapical stem is foot-shaped and has the same number and arrangement of spinules as the "foot" of *Amphisolenia palmata; i.e.*, a "heel-spinule" at some distance from the tip and three spinules at the tip; the spinules are of moderate strength or rather weak. The foot-shaped parts are generally somewhat narrower than the anterior portion of the antapical stem and 3–11 times longer than wide; in most specimens the "foot" of the main antapical stem is somewhat longer than that of the first branch. In our specimens the second branch has two to three, in most cases, rather weak spinules at the tip but no "heel-spinule." In the type specimen, as drawn by Schütt (1893, fig. 81), this branch has a "heel-spinule," but this is probably due to a mistake (compare the structure of the corresponding parts in *A. quadricauda* and *A. quinquecauda*).

The chromatophores are fairly numerous and large, ovoidal or spheroidal. In the midbody and in the antapical there are numerous groups of three to five very small, spheroidal bodies.

The length and the width of the body were measured in seven of our specimens; the proportions of the head and the neck in four of our specimens. All the

proportions were measured in two of our specimens and in the type specimen (Schütt, 1893, fig. 81) and in the specimen drawn by Okamura (1912, fig. 51a).

Dimensions: — Our specimens: Length of body, 739–1049 μ (average, 874 μ). Length of head, 10–11 μ. Length of neck, 53–60 μ (average, 57 μ). Length of anterior process and midbody, 203–216 μ. Width of midbody, 26–38 μ. Length of antapical stem in front of the first branch, 116–232 μ. Length of first branch, 271–290 μ. Length of second branch, 177–232 μ. Length of antapical stem behind second branch, 238–280 μ. Type specimen (Schütt, 1893, fig. 81): Length of body, 920 μ. Length of head, 10 μ. Length of neck, 57 μ. Length of anterior process and midbody, 232 μ. Width of midbody, 44 μ. Length of antapical stem in front of first branch, 387 μ. Length of first branch, 190 μ. Length of second branch, 148 μ. Length of antapical stem behind second branch, 175 μ. Okamura's (1912, fig. 51a) specimen: Length of body, 720 μ. Length of neck, 58 μ. Length of anterior process and midbody, 168 μ. Width of midbody, 41 μ. Length of antapical stem in front of first branch, 320 μ. Length of first branch, 100 μ. Length of second branch, 83 μ. Length of antapical stem behind second branch, 85 μ.

Variations: — As conceived in the present paper, *Amphisolenia thrinax* exhibits a rather remarkable variability. The following characters are the most variable: — the length of the body, the curvature of the longitudinal axis of the body, the width of the midbody, the relative length of the antapical stem in front of the first branch, the shape and the relative width of the antapical branches and the antapical stem behind the second branch, and the structure of the distal ends of the antapical stem and branches. Our specimens are rather strikingly variable in all these characters. Plate 12, figure 6, shows an atypic representative of the species. Future investigations may prove it necessary and feasible to divide the species into two or more systematic units.

Comparisons: — Most of the specimens found in the material of the Expedition and referred to *Amphisolenia thrinax* agree fairly closely with the type specimen of this species as figured by Schütt (1893). On the other hand, some of our specimens differ rather strikingly from the type specimen, especially in having the part of the antapical in front of the first branch very short and relatively long antapical branches. Their assignment must be regarded as questionable (Plate 12, fig. 6).

The specimen figured by Okamura (1912) under the name of *Amphisolenia thrinax* agrees very closely with the type specimen, and its assignment is undoubtedly correct. The tips of the antapical branches of his specimen are, however, probably misrepresented.

With regard to the relationships of this species, see the section on the comparisons of *Amphisolenia bifurcata* (p. 434).

Synonymy: — The species was established by Schütt (1893) under the name of *Amphisolenia thrinax*. This name was later used by several authors. Of these only Zacharias (1906) and Okamura (1912) give descriptions or drawings by means of which their determinations may be checked. Steuer (1910, 1911) and Oltmanns (1923) give reproductions of Schütt's (1893) figure of the type specimen.

Amphisolenia thrinax Zacharias (1906) is a synonym of *A. bifurcata* (see *A. bifurcata*, the section on synonymy, p. 435). *A. thrinax* Okamura (1912), on the other hand, is certainly correctly determined.

With regard to *Amphisolenia tripos* Schütt, see the historical discussion of the genus (p. 353).

Occurrence: — *Amphisolenia thrinax* is recorded at seventeen of the 127 stations. There are 3, 0, 1, 2, 6, and 5 stations on the six lines of the Expedition. Of these seventeen stations, four (4587, 4590, 4594, 4545) are in the Mexican Current; two (4691, 4697) are in the Easter Island Eddy; nine (4701, 4728, 4732, 4734, 4736, 4737, 4739, 4740, 4741) are in the South Equatorial Drift; two (4742, 4743) are in the South Equatorial Current. At three stations (4741, 4743, 4545) the species was found in surface catches only; at one station (4732) in a catch from 800–0 fathoms only; at two stations (4701, 4728) in catches from 800–0 fathoms as well as in catches from 300–0 fathoms; and at one station (4737) both in a catch from 100–0 fathoms and in one from 300–0 fathoms. The remaining records refer to catches from 300–0 fathoms only.

The temperature range of these seventeen stations at the surface was 72°–84°; the average was 79.0°. At Stations 4741, 4743, and 4545, where the species was found in surface catches, the surface temperatures ranged from 78°–80°; the average was 79.0°.

The frequency is less than 1%, except at four stations (4590, 4594, 4701, 4739), where it is 1%.

The type specimen of this species (Schütt, 1893) was probably taken in the tropical or the subtropical region of the Atlantic Ocean. Murray and Whitting (1899) found the species at three stations in the Sargasso Sea; Cleve (1901c) at one station in the Caribbean Sea and at seven stations in the region from near the east coast of America to near the west coast of Africa and between lat. 40° N. and lat. 21° S.; Hensen (1911) at several stations in the Sargasso Sea and the Canary Current. From the Gulf of Aden it is reported by Ostenfeld and Schmidt (1901); from the Arabian Sea by Cleve (1901a) and Schröder (1906a); from the Indian

Ocean by Schröder (1906a) and Karsten (1907). Karsten (1907) recorded it from not less than eighteen of the stations of the VALDIVIA Expedition, all located in the Indian Ocean, from near the west coast of Sumatra to near the east coast of Africa, and between lat. 8° N. and lat. 15° S. Okamura (1912) found the species in Japanese waters and Lemmermann (1899a) at lat. 6° 24′ N., long. 111° 4′ W., in the Pacific Equatorial Counter Current.

Most of the records referred to above are from catches made at or near the surface. Karsten (1907) found the species more frequent in deep waters than near the surface. He recorded the species as taken with closing net at the following

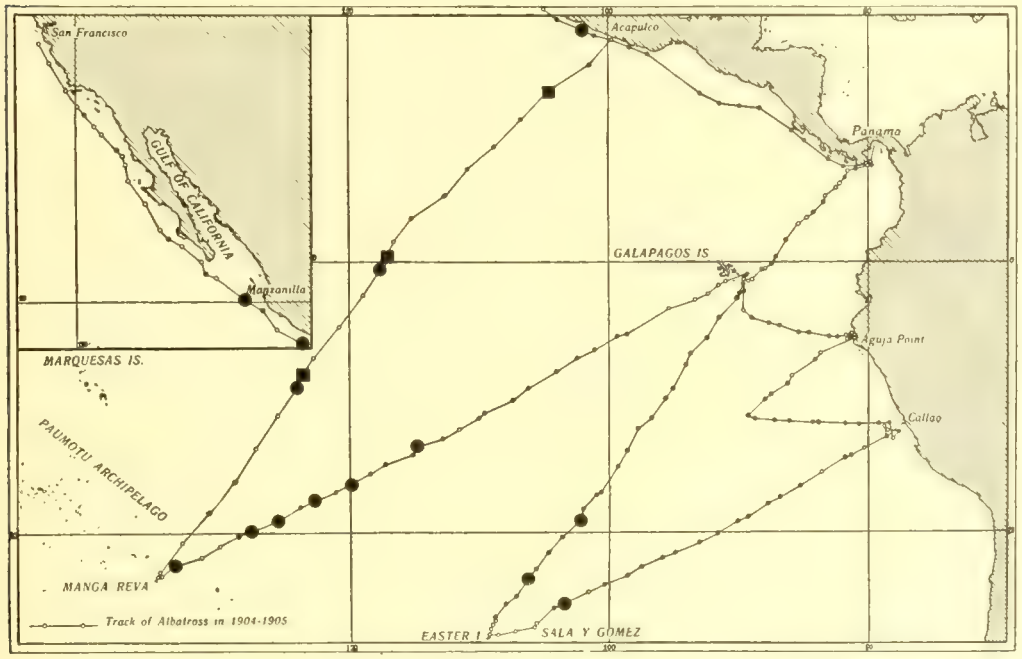

FIGURE 59.— Occurrence of *Amphisolenia thrinax* Schütt. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

stations: — Station 218, lat. 2° 29′ N., long. 76° 47′ E., 80–40 m., dead; 80–60 m., living; Station 221, lat. 40° 5′ S., long. 73° 24′ E., 185–145 m., dead, but with cytoplasmic contents; Station 236, lat. 40° 38′ S., long. 51° 16′ E., 100–65 m., living; Station 239, lat. 5° 42′ S., long. 43° 36′ E., 60–45 m., living; Station 268, lat. 9° 6′ N., long. 53° 41′ E., 21–4 m., living.

The species occurs in waters of the following temperatures and salinities: — Murray and Whitting (1899): Temperature range, 67°–74°; average of three observations 70.3°. Cleve (1901c): Temperature range, 67.0°–80.5°; mean of eight observations, 72.5°. Salinity range, 35.51–37.21; mean of four observations, 36.41.

Of the writers who have contributed to our knowledge of the distribution of this species only Schütt (1893) and Okamura (1912) give figures by means of which their determinations might be checked.

The species is eupelagic and widely distributed in tropical and subtropical seas. Its distribution in the region investigated by the Expedition is remarkable. Although it was found at not less than seventeen stations, it was not taken except in the Mexican Current, the Easter Island Eddy, the western part of the South Equatorial Drift, and in the South Equatorial Current. In other words, there are no records of this species from the California Current, the Panamic Area, the Galapagos Eddy, the Peruvian Current, and the eastern part of the South Equatorial Drift, which is under the influence of the last-mentioned current. It may be worth mentioning in this connection that the distributions of *Amphisolenia thrinax* and *Triposolenia longicornis*, both species with highly developed structural adaptations for flotation, are almost mutually exclusive according to our records.

Amphisolenia quadricauda Kofoid and Michener

Plate 13, fig. 1–6, 8. Figure 48, 56: 9

Amphisolenia quadricauda Kofoid & Michener, 1911, p. 293.

Diagnosis: — Resembling *Amphisolenia bifurcata*, but with three antapical branches. Length, 780 μ.

Eastern tropical Pacific.

Description: — The longitudinal axis of the body, the spread of the antapical branches, the head, the neck, the anterior process, and the midbody are as in *Amphisolenia thrinax*. The sulcal lists end at the flagellar pore; both of them have anteriorly a few, partly anastomosing cross-ribs, and the left list has a fission rib at the flagellar pore.

The antapical has three branches. The antapical stem in front of the first branch is straight, 2.7 times longer than the neck, and 0.6 the total length of the anterior process and the midbody; it is of about the same width throughout its whole length and somewhat wider than the neck. Of the three antapical branches the first is somewhat longer, the second and the third somewhat shorter than the antapical stem behind the third branch; the first branch is 5.8, the second 4.5, the third 4.0, and the antapical stem behind the third branch 5.0 the length of the neck. The first branch is gently sigmoid, the second and third gently sigmoid or gently concave posteriorly, and the antapical stem behind the third branch rather strikingly sigmoid. In the type specimen the three branches are of an almost

uniform thickness and about as wide as the antapical stem in front of the first branch; the antapical stem behind the third branch tapers posteriorly; its proximal half is about twice as wide as its distal half. The distal part of both the first branch and the antapical stem has the same shape and structure as in *Amphisolenia thrinax; i.e.*, it is foot-shaped and has a "heel-spinule" at some distance from the tip and three spinules at the tip. Each one of the second and third branches has two rather small spinules at the tip but no "heel-spinule."

The thecal wall has no structure. The distal parts of the anterior and the posterior antapical limbs are finely porulate; the two middle antapical limbs have no porulation. Along the base of each of the sulcal lists and on either side of the dorsal suture line of the neck there is a row of closely set pores. Fine porulation is also found on the head.

The proportions of one specimen, the type, were measured.

Dimensions: — Type specimen: Length of body, 780 μ. Length of head, 9 μ. Length of neck, 51 μ. Length of anterior process and midbody, 226 μ. Width of midbody, 38 μ. Length of antapical stem in front of first branch, 128 μ. Length of first branch, 284 μ. Length of second branch, 219 μ. Length of third branch, 194 μ. Length of antapical stem behind third branch, 245 μ.

Comparisons: — The description given above is based on the type specimen. With regard to the relationships of the species, see the section on the comparisons of *Amphisolenia bifurcata* (p. 434).

Occurrence: — *Amphisolenia quadricauda* is recorded at only one of the 127 stations. This station (4695) is on the fourth line of the Expedition and in the Easter Island Eddy. The depth is 300–0 fathoms, the surface temperature 74°, and the frequency less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4695 of the Expedition, which thus is the type locality. The single record station of this species is within the area of distribution established for *Amphisolenia thrinax*.

Amphisolenia quinquecauda Kofoid

Plate 13, fig. 7, 9–14. Figure 56: 10

Amphisolenia quinquecauda Kofoid, 1907a, p. 200, pl. 13, fig. 75; 1906c, p. 95. Kofoid & Michener, 1911, p. 293.

Diagnosis: — Resembling *Amphisolenia bifurcata*, but with four antapical branches. Length, 840 μ.

Eastern tropical Pacific.

Description: — The species differs from *Amphisolenia quadricauda* only in the following respects: — the antapical stem in front of the first branch is 5.8 times longer than the neck and 1.6 the total length of the anterior process and the midbody; however, this character is probably variable just as in *A. thrinax*. The most striking difference is that the antapical has four instead of three branches. Of these the second, third, and fourth are subequal and of about the same relative length and of the same shape and structure as the corresponding branches in *A. quadricauda*. The chromatophores are small, oblong, ellipsoidal, and numerous.

The proportions of one specimen, the type, were measured.

Dimensions: — Type specimen: Length of body, 840 μ. Length of head, 10 μ. Length of neck, 52 μ. Length of anterior process and midbody, 176 μ. Width of midbody, 44 μ. Length of antapical stem in front of first branch, 280 μ. Length of first branch, 316 μ. Length of second branch, 215 μ. Length of third branch, 187 μ. Length of fourth branch, 175 μ. Length of antapical stem behind fourth branch, 245 μ.

Comparisons: — The description given above is based on the type specimen. With regard to the relationships of the species, see the section on the comparisons of *Amphisolenia bifurcata* (p. 434).

Occurrence: — *Amphisolenia quinquecauda* is recorded at two of the 127 stations. These stations (4737, 4739) are on the fifth line of the Expedition and in the South Equatorial Drift. The samples are from 300–0 fathoms.

The surface temperatures of these stations were 81.5° and 70.0° respectively.

The frequency is less than 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4739 of the Expedition which thus is the type locality. The two record stations of this species are located in the area of distribution established for *Amphisolenia thrinax*.

Triposolenia Kofoid

Plate **14**, **15**, **27**. Figure 60–74

Triposolenia Kofoid, 1906c, p. 93, 101; 1906d, p. 117; 1906e, p. 127; 1907a, p. 201.

Diagnosis: — Body seemingly tripartite, with three long and narrow extensions arising from midbody, one anterior, made up of head, neck, and anterior process, and two posterior, the antapicals, one of which is dorsal, the other ventral in origin. The three extensions are generally subequal and approximately balanced; their length is 1.0–3.4 the dorsoventral diameter of midbody measured between bases of antapicals.

TYPE.— *Triposolenia truncata.*

Organology: — The original *longitudinal axis of the body* in Triposolenia is no longer a straight or nearly straight line as in most other genera of Dinophysoidae owing to the obliquity of the neck and of the anterior process, and to the position and shape of the original antapical. For the sake of simplicity in quantitative determinations of structural features a new, more or less arbitrary, longitudinal axis of the body has therefore been utilized in this paper. In all species except one, *T. ambulatrix*, the axis utilized is that perpendicular to the line joining the midpoints of the bases of the two antapicals which is equidistant from these midpoints (Figure 60: 1, 2). In *T. ambulatrix*, unfortunately, another line had to

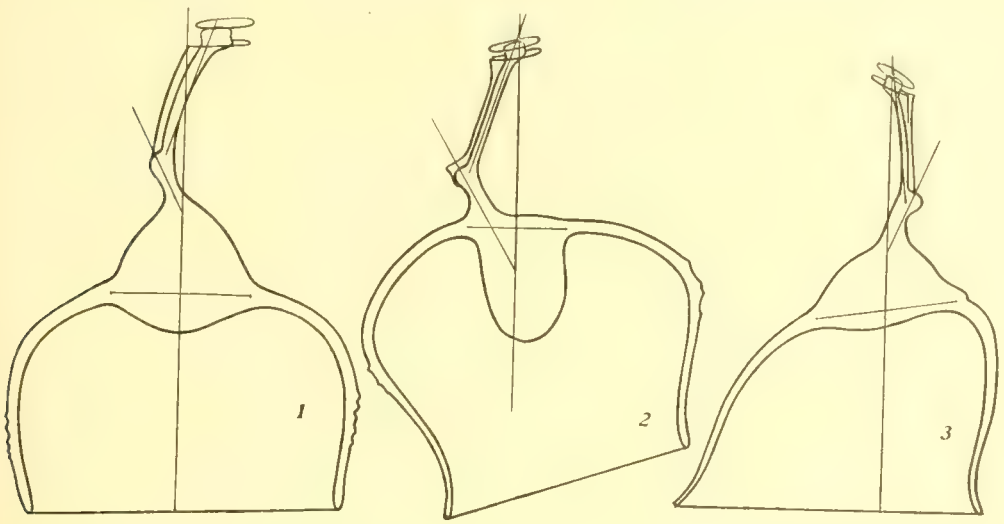

FIGURE 60.— Axes and angles utilized in our account of Triposolenia. In 1 and 2 the longitudinal axis of body is a perpendicular to line joining midpoints of bases of antapicals and equidistant from these midpoints; in 3 it is a perpendicular to line joining tips of antapicals and equidistant from midpoints of bases of these processes. The main axis of anterior process is drawn through midpoint of posterior end of process and through flagellar pore. The main axis of neck runs through midpoints of posterior and anterior ends of neck.

1, *Triposolenia intermedia*, sp. nov., left lateral view. × 360. Station 4613 (300–0 fathoms). This species is of the same type as *T. truncata, T. depressa, T. bicornis, T. longicornis*, and *T. fatula*. 2, *Triposolenia ramiciformis* Kofoid, left lateral view. × 360. Station 4613 (300–0 fathoms). This species has the same type as *T. exilis*. 3, *Triposolenia ambulatrix* Kofoid, right lateral view. × 360. Station 4713 (300–0 fathoms). This is the only species of this type.

be chosen. It is that perpendicular to the line joining the tips of the antapicals which is equidistant from the midpoints of the bases of these processes (Figure 60: 3).

These arbitrary longitudinal axes of the body have been chosen as bases of reference because of their relations to the plane of the girdle, to the longitudinal axis of the midbody, and to the antapicals. The plane of the girdle is nearly perpendicular to these arbitrary longitudinal axes, or at least more nearly so than

to the main axis of the neck. Presumably the axis of rotation in locomotion is approximately perpendicular to the plane of the girdle and is therefore nearly coincident with or at least nearly parallel to the longitudinal axis used in this paper.

The body is seemingly tripartite. It has three long and narrow extensions arising from the midbody: one anterior, made up of the head, the neck, and the anterior process; and two posterior, the antapicals, one of which is dorsal, the other ventral in origin. The three extensions are generally subequal and approximately balanced; their length is 1.0–3.4 the dorsoventral diameter of the midbody measured between the bases of the antapicals.

Triposolenia is remarkable because of the combination of asymmetry, both bilateral and dorsoventral, with an approximately balanced relation of the three extensions of the midbody.

The *head* (*hd.*, Figure 61) is short, its axial length being only 0.14–0.45 the length of the neck. It is composed of the very short epitheca, the girdle region covering nearly two thirds of its axial length, and of a short, expanded region at the anterior end of the neck. It is bilaterally compressed; its transdiameter is not much greater than that of the neck. Its dorsoventral diameter (its "width," according to the terminology utilized in this paper) is somewhat variable, 0.6–2.0 its axial length. In lateral view the anterior face of the head, the epitheca, is more or less convex in most species; in a few species it is flat and in *Triposolenia truncata* even quite concave. Sometimes the head is subhorizontal; sometimes it is more or less inclined, about 1°–20°, anteriorly, that is, its dorsal end is elevated. Because of the narrowness of the head, the inclination is difficult to determine accurately, and so this characteristic has not been utilized in our descriptions of species. The head passes more or less abruptly into the neck.

The *neck* (*n.*, Figure 61) is an elongate, slender, almost cylindrical, and somewhat oblique extension of the anterior process. Its length, measured in a straight line from the posteroventral point of the head to the flagellar pore (Figure 61), is 0.14–0.28 the length of the body. The distance between the midpoints of the bases of the antapicals is about 0.8–2.3 the length of the neck. The neck is 3–17 times longer than wide, of nearly uniform caliber throughout, or somewhat constricted anteriorly, almost straight or somewhat concave dorsally, and generally more or less deflected, about 1°–25°, dorsally from the longitudinal axis of the body.

The *anterior process* (*ant. p.*, Figure 61) is an extension of the midbody in the anteroventral direction at an angle of about 12° to 41° from the longitudinal axis of the body. In the subgenus Triposolenia it arises from about the middle of the anterior side of the midbody. In the subgenus Ramiciformia its point of origin is so decidedly shifted ventrally that the anteroventral margin of the midbody is

suppressed, and the ventral antapical and the anterior process bifurcate from a common, although but slightly developed projection of the midbody. The length of the anterior process, measured in a straight line from the midpoint of the flagellar pore to the midpoint of the posterior end of the process (Figure 61), is very hard or even impossible to establish with accuracy in many species. This is due to the fact that the process often merges gradually, sometimes even imperceptibly into the midbody, which, of course, prevents the establishment

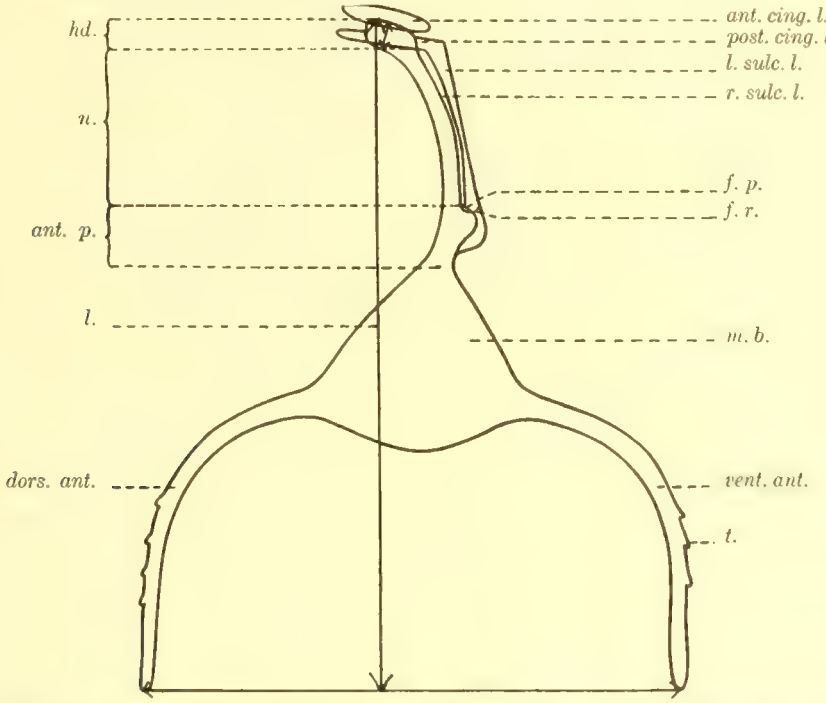

FIGURE 61.— *Triposolenia intermedia*, sp. nov., right lateral view. × 550. Station 4583 (300–0 fathoms). The length of body is measured from foremost point of head perpendicularly to line connecting tips of antapicals. Our method of measuring the (axial) length of head is indicated by bicapitate barbed line crossing the head. The length of neck is the distance in a straight line from posteroventral point of head to flagellar pore. The length of anterior process is the distance in a straight line from midpoint of flagellar pore to midpoint of posterior end of process. The dorsoventral diameter of midbody is the distance between midpoints of bases of antapicals. The lengths of antapicals are measured along curvatures from midpoints of bases to tips. The distance between tips of antapicals is measured between midpoints of tips.

Abbreviations:— *ant. cing. l.*, anterior cingular list; *ant. p.*, anterior process; *dors. ant.*, dorsal antapical; *f. p.*, flagellar pore; *f. r.*, fission rib; *hd.*, head; *l.*, length of body; *l. sulc. l.*, left sulcal list; *m. b.*, midbody; *n.*, neck; *post. cing. l.*, posterior cingular list; *r. sulc. l.*, right sulcal list; *t.*, tubercle; *vent. ant.*, ventral antapical.

of anything but an arbitrary posterior limit. However, it may be safe to say that the length does not exceed the axial length of the midbody; in most cases it evidently is decidedly less. The process is relatively stout, almost cylindrical or slightly compressed bilaterally, and anteriorly about twice as wide dorsoventrally as the neck. Anteriorly it expands around the *flagellar pore* (*f.p.*, Figure 61), forming a conspicuous, well-rounded *cytopharyngeal protuberance.*

The *midbody* (*m.b.*, Figure 61) is a centrally located enlargement of the body, strongly compressed bilaterally. Its axial length is about 0.15–0.33, its dorsoventral diameter 0.12–0.40, and its transdiameter 0.04–0.10 the length of the body. The distance from the flagellar pore to the midpoint of the postmargin of the midbody is from about 1.0 to nearly 3.0 the length of the neck. In the subgenus Triposolenia the midbody is in lateral view characterized by a subtriangular, subrotund or subellipsoidal shape. The corners of the triangle are marked by the anterior process and by the two antapicals. The three margins, the anterodorsal, anteroventral, and posterior margins, are more or less convex, almost straight or slightly concave. In most cases they are subequal in length; when differences in length do occur, the anteroventral margin generally is the shortest, due to the ventral dislocation of the anterior process, and the postmargin is the longest. In the subgenus Ramiciformia the anteroventral margin of the midbody is suppressed due to the ventral dislocation of the anterior process, the anterodorsal margin is straight or slightly convex or concave, and the postmargin is extended in a pendent, oblong, or rounded sack-shaped lobe.

The two *antapicals* (*dors. ant.* and *vent. ant.*, Figure 61) are sagittal extensions of the midbody, and are respectively ventral and dorsal in origin. They are prolongations of the thecal wall with protoplasmic core and are simple, long (1.8–3.4 times longer than the neck), narrow (6–50 times longer than wide), and approximately circular in cross-section. The dorsal antapical is in most species a trifle shorter than the ventral. Both antapicals stand, except in *Triposolenia ambulatrix*, in a balanced relation to the longitudinal axis of the body. In the species with balanced antapicals, the latter are always curved in the sagittal plane from a posterodorsal and a posteroventral direction, respectively, at their bases to a more or less posterior direction distally; sometimes they have a sigmoid curvature, being outwardly convex anteriorly and concave posteriorly. In some of these species the curvature is more or less localized in a major flexure or geniculation; in others, as in *T. truncata*, it is almost evenly distributed throughout the entire length. In *T. ambulatrix* the ventral antapical is abruptly deflected posterodorsally and has a more or less pronounced sigmoid curvature, its tip being deflected ventrally. The dorsal antapical of this species is deflected dorsally to such a degree that its balance with the ventral one is destroyed; it has a moderate dorsal convexity, and its tip is sometimes deflected dorsally which gives to the antapical a sigmoid shape. In addition to the curvature in the sagittal plane there is in all species a slight bilateral asymmetry, in that the antapicals do not lie in the sagittal plane of the midbody in their total extension but are slightly bent to the right in the middle or anterior regions and posteriorly to the left; the

dorsal antapical exhibits generally more of the posterior curvature than the ventral. The tips of the antapicals are sometimes rounded and without *spinules* (*T. exilis*, Kofoid, 1906c, pl. 17, fig. 8); sometimes they are more or less truncate with dorsoventral spinules, as in *T. truncata*, or with lateral spinules, as in *T. depressa*. Except in *T. truncata* and in some specimens of *T. ambulatrix*, the outer margins of the major flexures or adjacent regions bear 2–5, rarely 1, 6, or 7, small elevations or *tubercles* (*t.*, Figure 61), each pierced by a pore. The tubercles lie close to the sagittal suture of the valves and are conical and often deflected posteriorly. In the subgenus Ramiciformia they are farther in front than in the subgenus Triposolenia.

The question is still open whether the ventral or the dorsal antapical is the original posterior part of the body. In Amphisolenia the branches of the antapical appear to be ventral in origin. In Dinophysis and Dinofurcula the accessory posterior process seems to be dorsal. The branching has undoubtedly originated independently in these three genera, as well as in Triposolenia. In attempting to find out which of the two antapicals in Triposolenia does correspond to the original posterior part of the body, we are therefore probably not justified in basing our conclusions on the conditions in the other known genera of this tribe.

The *transverse furrow* (Plate **14**, fig. 1, 7, 14) forms a slightly oblique equatorial band around the small head, covering nearly two thirds of its axial length. Its distal part is not displaced posteriorly, *i.e.*, the furrow does not form a spiral about the head. Sometimes the furrow is nearly perpendicular to the arbitrary longitudinal axis of the body used in this paper, but in most cases it is somewhat inclined anteriorly, due to the anterior inclination of the head. Its anterior inclination is, as a rule, somewhat less than that of the head. Its floor is sometimes slightly convex, sometimes flattened or more or less concave; this character seems to vary even within the species.

The *longitudinal furrow* (Plate **14**, fig. 1, 7, 14) is long and narrow. It is narrower than the neck and extends on the ventral side of the right valve of the neck in about a straight line from the transverse furrow to a little beyond the posterior end of the neck. It does not extend beyond the girdle, *i.e.*, into the epitheca. It is at most but slightly impressed.

The *lists of the furrows* are not excessively developed. They arise from low and narrow basal ridges (Plate **14**, fig. 7, 14) and are hyaline, exceedingly delicate, and mostly furnished with simple, radial ribs. Frequently the basal ridges of the cingular lists are connected by a number of low and narrow ridges crossing the transverse furrow. The ventral ones of these cross-ridges are first and best developed.

The *anterior cingular list* (*ant. cing. l.*, Figure 61) is a flaring sheet, open

ventrally, of moderate and almost uniform width throughout the greater part of its length, about as wide as or about two to three times wider than the transverse furrow. It has, on each valve, about five to twelve simple and nearly equidistant cross-ribs. Of these ribs two near the ventral suture of the valves are in many cases a little stronger than the others. On the dorsal side of the head the list flares anteriorly at an angle of about 10° to 40° from the transverse plane of the girdle, and it is frequently slightly concave ventrally.

The *posterior cingular list* (*post. cing. l.*, Figure 61) either has about the same width, inclination, and structure as the anterior, or else it is somewhat less inclined anteriorly, sometimes even subhorizontal, and has somewhat less-developed ribs.

The *sulcal lists* (*r. sulc. l.*, and *l. sulc. l.*), which form a direct continuation of the posterior cingular list, run about parallel to each other along the whole length of the neck. Posteriorly they diverge a little to enclose the flagellar pore. The left list approaches the median line just behind the pore, continues posteriorly for a short distance beyond the pore along the ventral side of the anterior process, and dies out within a short distance of the pore. The right list, which continues for but a very short distance beyond the flagellar pore, ends on the side of the cytopharyngeal protuberance. Both lists are of moderate width, generally somewhat narrower than the cingular lists; the right is slightly narrower than the left. The right decreases somewhat in width posteriorly; the same is true in the case of the left, except near the flagellar pore, where it increases somewhat in width. Their width and shape are somewhat variable even within the species. The ribs of the sulcal lists are different in the various species; they are of about the same type as, but, as a rule, somewhat less developed than, those of the cingular lists. Near the sagittal plane, just behind the flagellar pore, the left list in most cases has a fairly distinct rib (*f.r.*, Figure 61), supposed by us to be homologous with the *fission rib* of the left sulcal list in other genera of Dinophysoidae (see the section on the reproduction of the genus, p. 453).

The *flagellar pore* (*f.p.*, Figure 61) is a fairly large opening at the posteroventral end of the neck, or to express it in another way, at the anteroventral end of the anterior process, and leads into a narrow funnel, the *flagellar fundus*. It is ventrally surrounded by the cytopharyngeal protuberance, and its left lip is somewhat higher than the right. It is therefore directed anteriorly and somewhat to the right.

The *transverse flagellum* (*tr. fl.*, Kofoid, 1906c, pl. 16, fig. 6) arises in the flagellar pore and passes anteriorly between the sulcal lists and encircles the head from the left around to the right as in other girdled dinoflagellates.

The *longitudinal flagellum* has not been seen by us, nor is there any clear statement in the literature that this flagellum has been seen by any other investigator. Hjort (1911, pl. 12: 3) gives a reproduction of Kofoid's (1906c, pl. 15, fig. 1) drawing of the type specimen of *Triposolenia bicornis* to which a long trailing flagellum has been added. However, this addition probably is purely diagrammatical. The posterior displacement of the flagellar pore is suggestive of a possible reduction of this flagellum to a rudimentary state.

The *thecal wall* is of nearly uniform thickness except on the concave faces of the antapicals, where, as in Ceratium, it is somewhat thickened, especially in the more robust individuals. In most species it is hyaline and under low magnifications apparently structureless. When these species are examined under high magnifications, however, the wall is found to be very faintly and minutely spotted or flecked; sometimes it also is striate. In but a single species, *Triposolenia truncata*, are there plainly visible pits and reticulation; this is undoubtedly to be considered the more primitive condition. Pores are found only in the antapical tubercles and along the sagittal suture on the ventral side of the neck.

The *sagittal suture* is not structurally marked except by a faint line, or a few scattered pores along the ventral side of the neck or in the tubercles on the major flexures of the antapicals. The three *plates*, epithecal, cingular, and hypothecal, of each valve have never been found parted in the specimens thus far observed.

The *protoplasmic contents* (Plate 15, fig. 2) are very hyaline and coarsely granular. The *nucleus*, which is located in the midbody, is compressed and ellipsoidal, and has a moniliform chromatin reticulum. In the subgenus Ramiciformia, the nucleus and the greater part of the protoplasm are found in the pendent region of the midbody. Near the nucleus is found a *pusule*, which opens by a slender canal into the flagellar pore. One or more *accessory pusules*, also opening into the flagellar pore, may lie near it in the plasma. Occasionally the plasma is crowded with highly refractive ellipsoidal *metaplasmic bodies* of amyloid character. In many individuals it is possible to find small irregular, very pale yellowish-green, sometimes nearly colorless *chromatophores*. No species appears to possess the protoplasmic structures with a characteristic pattern in either form or distribution.

The *length of the body*, measured from the foremost point of the head perpendicularly to the line connecting the tips of the antapicals (Figure 61), is a fairly variable character even within the various species. The range of variation in length for the genus as a whole thus far established is 92 μ to 243 μ.

Reproduction: — Neither sexual reproduction nor binary fission has been observed as yet. Nor is there any evidence of a megacytic phase preceding binary fission.

The entire course of the line of fission is not known with certainty. Most probably it is as follows: — On the dorsal side of the body, along the middle of the head, neck, anterior process, midbody and antapicals. On the ventral side of the body, along the middle of the head, along the left side of the sulcus, to the left of the flagellar pore, crossing the left sulcal list just behind this pore, and along the middle of the anterior process, midbody, and antapicals. This assumption is supported by the conditions in Amphisolenia, as established in the present paper (Plate **13**, fig. 1–6, 8), and by the following facts which have been indicated in the section on the organology. The left sulcal list swings in toward the median line just behind the flagellar pore. Near the sagittal plane, just behind the pore, it has usually a fine rib, behind which it continues for a short distance along the ventral side of the anterior process. This rib is, according to our opinion, homologous with the fisson rib of the left sulcal list in other genera of this tribe, *e.g.*, Amphisolenia, Phalacroma, and Dinophysis (Plate **13**, fig. 6; Plate **1**, fig. 6; Plate **5**, fig. 3). Since no representative of Triposolenia has been observed in a stage of division, it cannot be stated positively that the left sulcal list is parted at this rib, and that its anterior and posterior parts are going to the left and to the right valve respectively, but the homologies here indicated make such a division probable. In any case, the continuation of the left sulcal list behind "the fission rib" in *Triposolenia* runs near the sagittal plane and may well belong to the right valve.

Distribution: — Our present knowledge of the general oceanic distribution of Triposolenia must be regarded as very incomplete. The distributional data available, given by Kofoid (1906c, 1907a) and Jörgensen (1923), are accompanied by drawings and thus can be checked.

The genus is marine and probably exclusively eupelagic. We have found it to be extensively distributed throughout the tropical, subtropical, and warm-temperate regions of the Eastern Pacific, and it has been recorded from the southwest coast of Portugal, from the Mediterranean, and from the Marmora Sea by Jörgensen (1923). It is therefore probably of world-wide distribution in tropical, subtropical, and warm-temperate waters. The fact that it has not been found as yet except in the regions mentioned above is presumably largely due to its very rare occurrence at the surface and the limitation of most plankton collections to surface levels.

The typical habitat of the genus appears to be the deeper levels of photosynthesis, predominantly between 200 and 100 meters (Jörgensen, 1923, p. 42, 43). Only one of the eight known species, *Triposolenia bicornis*, has been recorded

as yet from surface waters (Kofoid, 1906c, p. 107). No closing-net data have been published as yet.

All the species seem to be rare. Even the most frequent members of the genus, *Triposolenia bicornis* and *T. ramiciformis*, have never been found up till the present time except in small numbers.

The most outstanding peculiarity of the distribution of Triposolenia according to the data of the Expedition is that the genus did not occur in any of the eighty-one surface catches nor in any of the twenty-four samples of Salpa stomachs from specimens taken in surface waters, although it is recorded from as many as fifty-nine (46.5%) out of the 127 stations of the Expedition at which Dinoflagellates were found. Most of the records are from vertical hauls from 300–0 fathoms, some from vertical hauls from 800, 400, 150, 100–0 fathoms. Vertical hauls were made at only sixty-eight out of the 127 stations. Representatives of the genus thus were found at no less than 86.8% of the stations at which vertical hauls were made.

Disregarding the stations at which surface catches only were made, the record stations of Triposolenia are distributed over the area covered by the Expedition in the following manner (Plate 27): —

4 (100.0%) out of the 4 stations in the California Current
5 (100.0%) out of the 5 stations in the Mexican Current
6 (100.0%) out of the 6 stations in the Panamic Area
16 (76.2%) out of the 21 stations in the Peruvian Current
3 (60.0%) out of the 5 stations in the Easter Island Eddy
2 (100.0%) out of the 2 stations in the Galapagos Eddy
22 (95.7%) out of the 23 stations in the South Equatorial Drift
1 (100.0%) out of the 1 station in the South Equatorial Current

No vertical collections were made in the Equatorial Counter Current or in the North Equatorial Current.

The numbers of these fifty-nine stations are as follows: — 4571, 4574, 4580, 4583 (California Current); 4587, 4590, 4594, 4598, 4605 (Mexican Current); 4609, 4613, 4617, 4634, 4637, 4638 (Panamic Area); 4648, 4650, 4652, 4655, 4657, 4659, 4662, 4663, 4665, 4666, 4667, 4668, 4670, 4671, 4675, 4676 (Peruvian Current); 4691, 4697, 4699 (Easter Island Eddy); 4713, 4715 (Galapagos Eddy); 4679, 4681, 4683, 4685, 4687, 4701, 4705, 4707, 4709, 4711, 4717, 4719, 4721, 4722, 4724, 4728, 4730, 4732, 4734, 4737, 4739, 4740 (South Equatorial Drift); 4742 (South Equatorial Current).

The fifty-nine stations at which Triposolenia was found (Plate 27) are scat-

tered over the whole area covered by the Expedition and do not show any pronounced concentration in any of the regions into which this area has been divided. In the California Current, the Mexican Current, the Panamic Area, the Galapagos Eddy, and the South Equatorial Current the genus occurred at all the stations at which vertical hauls were made; in the South Equatorial Drift it was found at no less than twenty-two out of the twenty-three stations with vertical hauls. In the Peruvian Current it occurred at only sixteen out of the twenty-one stations with vertical hauls and in the Easter Island Eddy at only three out of the five stations with vertical hauls. If, on the other hand, the number of records of species, instead of the number of record stations, is considered, there appears to be a moderate concentration of the genus in the Peruvian Current and in the region of the South Equatorial Drift that is under the direct influence of this current, but in the Easter Island Eddy the genus is strikingly scarce. In the Easter Island Eddy the genus is recorded three times only; two of these three records are of *T. bicornis*, the remaining one of *T. ramiciformis*.

When the distribution of Triposolenia (Plate 27) in the region investigated by the Expedition is compared with that of the closely related Amphisolenia (Plate 26), we find the following outstanding similarities and differences. (*1*) Both genera have been found throughout the whole region investigated. (*2*) While in Triposolenia no species has been recorded from the surface, several species of Amphisolenia have been found in surface catches. However, most of the species of Amphisolenia appear also to be more or less limited to the deeper levels of photosynthesis. (*3*) While in Triposolenia there is a relatively large number of records of species in the Peruvian Current and in the portion of the South Equatorial Drift that is under the direct influence of this current, a moderate number of records of species in the western portion of the South Equatorial Drift, and a very small number of records of species in the Easter Island Eddy, there is in Amphisolenia a strikingly small number of records of species in the Peruvian Current and in the portion of the South Equatorial Drift that is under the direct influence of this current and a remarkably large number of records of species in the western and middle portions of the South Equatorial Drift and in the Easter Island Eddy.

In order to understand the differences between the horizontal distribution of Triposolenia and that of Amphisolenia in the area investigated by the Expedition, it is necessary to consider the horizontal distributions of the individual species of these two genera according to the data of the Expedition.

Disregarding the species of rare occurrence, the species of Triposolenia be-

long to any one of three main distributional types. Type 1: This type is characterized by an even distribution throughout the area investigated by the Expedition. It is represented by one species only, viz., *T. bicornis*, which according to available data is the most common representative of this genus (Figure 67). Type 2: This type is characterized by a distribution in waters of high average temperature. It is represented by one species only, viz., *T. truncata* (Figure 63). Most of the record stations of this species are in the Panamic Area and in the western portion of the South Equatorial Drift. In the relatively cool Peruvian Current and in the portion of the South Equatorial Drift that is under the direct influence of this current, this species appears to be either very rare or absent. Type 3: This type is characterized by a comparatively frequent occurrence in the relatively cool Peruvian Current and the portion of the South Equatorial Drift that is under the direct influence of this current. It comprises three of the most frequent species of this genus. Its most typical representative is *T. longicornis* (Figure 70). This species is recorded at a rather large number of stations in the Peruvian Current and the eastern portion of the South Equatorial Drift but has never been found in the Easter Island Eddy and in the western portion of the South Equatorial Drift. Another typical member of this group is *T. ramiciformis*, which next to *T. bicornis* is the most common species of this genus. *T. ramiciformis* (Figure 74) is recorded at forty of the 127 stations of the Expedition. Of these forty stations no less than twenty-six are in the Peruvian Current and in the portion of the South Equatorial Drift that is under the direct influence of this current, and two are in the Galapagos Eddy, which also is directly influenced by this current. In the western portion of the South Equatorial Drift and in the Easter Island Eddy, this species was found altogether at two stations only. *T. depressa* (Figure 65) also belongs to this group, but its distribution is somewhat atypical. It prevails in the Peruvian Current and in the eastern portion of the South Equatorial Drift and is absent in the Easter Island Eddy, but there are also some record stations in the western portion of the South Equatorial Drift.

The most frequent species of Amphisolenia belong to any one of three main distributional types. Type 1: This type is characterized by an almost even distribution throughout the area investigated by the Expedition. As examples *A. extensa* (Figure 52) and *A. globifera* (Figure 53) may be mentioned. Type 2: The species of this distributional type occur throughout the whole area investigated, but they are less frequent in the relatively cool Peruvian Current and in the eastern portion of the South Equatorial Drift, which is directly influenced by this current, than they are in the western portion of the South Equatorial Drift. This

type includes *A. bidentata* (Figure 55) and *A. lemmermanni* (Figure 57). Type 3: The species of this type occur in waters of high average temperature. Their main habitat appears to be the western portion of the South Equatorial Drift and the Easter Island Eddy, and they have not been found as yet in the Peruvian Current and in the eastern portion of the South Equatorial Drift. This type includes *A. schauinslandi* (Figure 51), *A. thrinax* (Figure 59), and probably *A. rectangulata*, *A. bifurcata*, *A. quadricauda*, and *A. quinquecauda*.

The differences between the horizontal distribution of Triposolenia and that of Amphisolenia mentioned above are therefore due to the fact that in Triposolenia most of the species of relatively frequent occurrence prevail in the comparatively cool Peruvian Current and in the portion of the South Equatorial Drift that is directly influenced by this current, while in Amphisolenia most of the relatively common species are warm-water forms with their principal habitat in the middle and western portions of the South Equatorial Drift and in the Easter Island Eddy and are absent or of rare occurrence in the Peruvian Current and in the eastern portion of the South Equatorial Drift. The similarities in the horizontal distribution of Triposolenia and Amphisolenia are due to the fact that both genera include species of rather wide amplitude of thermal adaptation and therefore of more or less even distribution throughout the area investigated by the Expedition.

The prevalence of the most frequent species of Triposolenia in the Peruvian Current and in the eastern portion of the South Equatorial Drift indicates that these forms have their optimum habitat in relatively cool waters. This is presumably the explanation of the peculiar fact that this genus never was found in the surface catches of the Expedition, although it appears to be structurally well adapted to waters of low buoyancy. Its species are also less adapted by structure to vertical migration than are the slender, linear species of Amphisolenia.

There are 156 records of species of Triposolenia from vertical catches from 300 (800, 400, 150, 100)–0 fathoms. Out of these 156 records only three (1.9%; Stations 4571, 4648, 4663) showed a frequency of 2%; thirty-six (23.1%; Stations 4574, 4580, 4583, 4598 [3 records], 4605, 4613, 4617 [2 records], 4634, 4637, 4648, 4650 [2 records], 4652, 4655, 4657, 4659, 4662, 4666, 4668 [2 records], 4671 [2 records], 4675, 4701, 4713 [2 records], 4715 [2 records], 4724, 4730, 4739, 4742 [2 records]) showed a frequency of 1%; 117 (75.0%) showed a frequency of less than 1%.

Coincident occurrence of different species of Triposolenia is recorded at the following of the fifty-nine stations mentioned above: six species occurred coinci-

dently at two stations (3.4%; Stations 4580, 4711); five species at five stations (8.5%; Stations 4583, 4598, 4613, 4709, 4713); four species at seven stations (11.9%; Stations 4650, 4652, 4659, 4667, 4721, 4724, 4742); three species at sixteen stations (27.1%; Stations 4587, 4617, 4637, 4662, 4668, 4671, 4676, 4681, 4683, 4701, 4705, 4715, 4717, 4730, 4732, 4740); and two species at fourteen stations (23.7%; Stations 4594, 4605, 4634, 4638, 4648, 4655, 4665, 4670, 4675, 4679, 4707, 4722, 4737, 4739).

Historical Discussion

The genus Triposolenia was established by Kofoid (1906c), who founded it on five new species, *T. truncata*, *T. depressa*, *T. bicornis*, *T. ramiciformis*, and *T. exilis*. In a later paper (1907a) the same author described three more species, *T. longicornis*, *T. fatula*, and *T. ambulatrix*. These eight species, besides a new one, *T. intermedia*, described in the present paper, are the only species of this genus known at the present time.

In Kofoid's works (1906c, d, e) an extensive description and discussion of the genus as a whole are given, and a subdivision of the genus in two subgenera, Posterocornia and Ramiciformia, is suggested. The only writer besides Kofoid, who has recorded the genus, is Jörgensen (1923). This author describes, figures, and gives the distribution of three of the species established by Kofoid but does not treat the genus as a whole.

Kofoid (1906c, p. 93) suggests that *Amphisolenia tripos* (*nomen nudum*) Schütt (1893) may refer to a species of Triposolenia. However, there is no information in the literature as to the structure of this species (see the section on the historical discussion of the genus Amphisolenia, p. 353).

Adaptive and Systematic Value of the Characters. Principles Used in the Descriptions of the Species

The genus Triposolenia, as previously mentioned, is confined to waters of tropical, subtropical, and warm-temperate nature or origin, in other words, to waters of comparatively low viscosity. Its peculiar organization is probably in part to be interpreted as an adaptation to the relatively low carrying capacity of these waters.

The asymmetry caused by the deflection to the left of the posterior parts of the antapicals has been analyzed by Kofoid (1906e) and shown to be adaptive. Its effect is to turn the organism upon its right face, as soon as it begins to descend while oriented with the anterior end of the body uppermost. In this sidewise

position the body offers a maximal surface of resistance to the downward movement and thus facilitates the remaining of the organism on a level of optimum illumination. For further information on this interesting point, reference is made to the mentioned article by Kofoid (1906e). For further discussion of the adaptive significance of the organization of Triposolenia, see Kofoid (1906c, p. 95, 96; 1906d, p. 121; 1906e, p. 129).

The characters by which the species of this genus have been distinguished from each other are principally the shape of the head, the inclination, curvature, and relative length and width of the neck, the shape of the midbody, and the origin, relative length, curvature, spread, and structure of the antapicals. Pronounced structural differentiation of the thecal wall appears only in *Triposolenia truncata* among the species of this genus thus far known.

Although the size of the body is a character of rather great variability within the species, it is not without systematic value. In support of this statement, the following examples may be given: — *Triposolenia depressa* and *T. truncata*, 92–122 μ and 109–145 μ long respectively, are comparatively small species; while *T. longicornis* and *T. fatula* are relatively large, measuring 210–243 μ and 175 μ in length, respectively.

The structures least modified within the genus are the anterior process and the cingular and sulcal lists. Differences in the position, size, and shape of nucleus and pusules and in the number, form, and color of the chromatophores and metaplastic inclusions appear to have little significance in the matter of specific distinctions.

The individual species characters are all subject to variations of the fluctuating kind, in varying degrees of amplitude. Thus the relative length of the neck and the shape of the margins of the midbody, in lateral view, are rather variable. The greatest fluctuations are perhaps found in the antapicals, in their relative length and width, in their spread, in the degree and localization of their curvature, in the number and distribution of their tubercles, and in the form and structure of their tips. Fluctuations are least evident in the anterior process and in the head, but, on the other hand, these parts exhibit, generally speaking, rather slight differences in the various species.

A comparison between the list of the characters used in this paper for the differentiation of the species and the list of the characters subject to decided variations of the fluctuating kind shows that these lists are almost identical. From this follows that it is not possible, as a rule, to separate the species by single characters; the totality of the characters must be considered (*cf.* Kofoid, 1906d).

The great variability and the scarcity of the material available have rendered the establishment of the species very difficult. The division into species as presented in this paper should in some cases be regarded as tentative.

The following principles have been used in describing the species of this genus: —

(*1*) When not otherwise stated, all characteristics refer to specimens in lateral view.

(*2*) In describing the proportions of the body, the length of the neck, measured in a straight line from the posteroventral point of the head to the flagellar pore (Figure 61), has been used as a unit.

(*3*) The methods of measuring axes and angles used in this paper are shown in Figure 60.

(*4*) The methods used in measuring the length of the body and the proportions of the different parts of the body are shown in Figure 61.

(*5*) The thecal wall is without structure in all the species in whose diagnoses this character is not mentioned.

Subdivisions. Relationships between the Subgenera and among the Species

The genus Triposolenia may conveniently be divided into two subgenera, according to the position of the anterior process, the points of origin of the antapicals, and the shape of the midbody. These subgenera, Triposolenia and Ramiciformia, most probably represent natural systematic units and are, as far as our present knowledge goes, not connected by any transitional forms. They may be defined as follows: —

Subgenus 1. Triposolenia nobis, nom. subgen. nov.— Anterior process arises at or near the middle of anterior side of midbody. Midbody centrally located; in lateral view subtriangular, more or less rounded triangular, or subellipsoidal; with three distinct margins; postmargin not excessively developed. Antapicals arising from posterior part of midbody. Distance in a straight line from center of midbody to tip of ventral antapical always exceeds distance from center of midbody to apex of head.

Subgenus 2. Ramiciformia Kofoid.— Point of origin of anterior process shifted to near ventral margin of midbody. Midbody in lateral view ranging from oblong to rounded sack-shaped; with only two distinct margins, the anteroventral margin of the previous subgenus being suppressed; postmargin extended in a pendent lobe. Antapicals arising from anterior part of pendent midbody.

The subgenus Triposolenia corresponds to the subgenus Posterocornia Kofoid (1906c, p. 101), which thus becomes a synonym. It comprises seven of the nine species hitherto known, viz., *T. truncata*, *T. depressa*, *T. bicornis*, *T. longicornis*, *T. ambulatrix*, and *T. fatula*, all described by Kofoid in previous papers (1906c and 1907a), and *T. intermedia*, established in the present paper. The type of this subgenus (and thus of the genus) is *T. truncata*.

The subgenus Ramiciformia was established by Kofoid (1906c, p. 101) and comprises thus far only two species, viz., *Triposolenia ramiciformis*, which is the type of the subgenus, and *T. exilis*, both previously described by Kofoid (1906c). By a *lapsus calami* this subgenus was named Ramiciformis by Kofoid (1906c, p. 97); *cf.* Article 19 of the International Rules of Zoölogical Nomenclature.

If *Triposolenia truncata* be the most primitive species of this genus thus far known (p. 463), then the subgenus Triposolenia is more primitive than the subgenus Ramiciformia. The latter probably arose from a member of the former. However, as previously mentioned, no transitional forms between the two subgenera are known at the present time.

The present knowledge of the subgenus Triposolenia is too limited to allow any well-founded statements as to the relationships between the species. *T. depressa*, *T. bicornis*, *T. intermedia*, and *T. longicornis* appear to be very closely connected. *T. depressa* and *T. bicornis* intergrade; so probably do *T. bicornis* and *T. intermedia;* and *T. intermedia* appears to form a connecting link between *T. bicornis* and *T. longicornis*. Specimens are sometimes found which in the light of our present knowledge may be assigned to either *T. depressa* or *T. bicornis*. The sizes of these four species probably give a good indication of their mutual relationships. *T. depressa* is 92–122 μ long; *T. bicornis* is 120–153 μ long; *T. intermedia*, 165–177 μ; *T. longicornis*, 210–243 μ. *T. fatula* is probably rather closely related to *T. longicornis*. *T. truncata* and *T. ambulatrix*, especially the former, occupy rather isolated positions. As has previously been shown, *T. truncata* is probably the most primitive known member of its genus.

Key to the Species of Triposolenia

1. Midbody subtriangular; its postmargin not extended in a pendent lobe (subgenus Triposolenia)....2.
1. Postmargin of midbody extended in a pendent lobe (subgenus Ramiciformia).....8.
2. Epitheca quite concave; thecal wall profusely and strikingly pitted.....*truncata* Kofoid.
2. Epitheca convex or more or less flattened; thecal wall structureless or almost so.....3.
3. Antapicals strikingly asymmetrical, both deflected dorsally, especially the dorsal.*ambulatrix* Kofoid.
3. Antapicals almost symmetrical or of moderate asymmetry, balanced or almost so.....4.
4. Antapicals very long and slender, the ventral three times or more longer than neck.....5.
4. Antapicals less than three times longer than neck.....6.
5. Head 1.3–2.0 times longer than wide; margins of midbody subequal; antapicals subsymmetrical. *longicornis* Kofoid.

5. Head subspheroidal; anteroventral margin of midbody shorter than the two others; antapicals of moderate asymmetry ..... *fatula* Kofoid.
6. Rather large, more than 160 μ; head wider than long ..... *intermedia*, sp. nov.
6. Medium-sized or small, less that 160 μ; head subspheroidal ..... 7.
7. Length almost always less than 120 μ; longitudinal axis of midbody in most cases foreshortened; geniculation scarcely evident in antapicals ..... *depressa* Kofoid.
7. Length almost always more than 120 μ; longitudinal axis of midbody not foreshortened; antapicals generally geniculate ..... *bicornis* Kofoid.
8. Distance between antapicals at level of tips 2.0 and at level of midbody 2.5 the length of midbody. *ramiciformis* Kofoid.
8. Distance between antapicals at level of tips as well as at level of midbody 1.6 the length of midbody. *exilis* Kofoid.

Subgenus 1. TRIPOSOLENIA nobis, nom. subgen. nov.— All the seven species that belong to this subgenus have been found in the material of the Expedition. They have been treated in this paper in the following order indicative of relationships: — *Triposolenia truncata, T. depressa, T. bicornis, T. intermedia, T. longicornis, T. fatula,* and *T. ambulatrix.*

TRIPOSOLENIA TRUNCATA Kofoid

Plate **14**, fig. 1–3. Figure 62, 63

Triposolenia truncata KOFOID, 1906c, p. 96, 98, 101, 102, 105, 106, 107, pl. 16, fig. 5; 1906d, p. 117, 118, 119, 120. JÖRGENSEN, 1923, p. 43, fig. 64.

Diagnosis: — Head 1.5–2.0 times wider than long. Epitheca concave. Distance between bases of antapicals 1.8–2.3 the length of neck which is three to five times longer than wide and straight or slightly curved. Midbody subtriangular or subrotund; its three margins subequal and convex. Antapicals 2.7–3.4 times longer than neck, generally stout, subsymmetrical; geniculation scarcely evident; no tubercles; tips truncate and spinulate. Wall profusely pitted; neck reticulated. Length, 109–145 μ.

Tropical, subtropical, and warm-temperate regions of Eastern Pacific; Mediterranean; Marmora Sea.

Description: — The head is 0.37 (0.31–0.45) the length of the neck and 1.5–2.0 times wider than long. The anterior face of the epitheca is quite concave. The transverse furrow is flat or generally somewhat concave. The anterior cingular list is 1.5–2.0 times wider than the transverse furrow and has, on each valve, five to six generally slightly developed ribs.

The neck is comparatively short and thick. The distance between the midpoints of the bases of the antapicals is 2.1 (1.8–2.3) the length of the neck which is three to five times longer than wide. The neck is rather slightly curved dorsally, exceptionally almost straight, with a dorsal deflection of 5° (1°–14°) from the longitudinal axis of the body. The left sulcal list continues beyond the flagellar

pore nearly to the midbody. It has, at least in some specimens, three ribs behind this pore; the anteriormost of these ribs is the fission rib.

The anterior process arises at or near the middle of the anterior margin of the midbody and is deflected ventrally 34° (28°–41°) from the longitudinal axis of the body. It measures 0.81 (0.74–0.86) the length of the neck. The distance from the flagellar pore to the midpoint of the postmargin of the midbody is 2.6 (2.3–2.8) times longer than the neck.

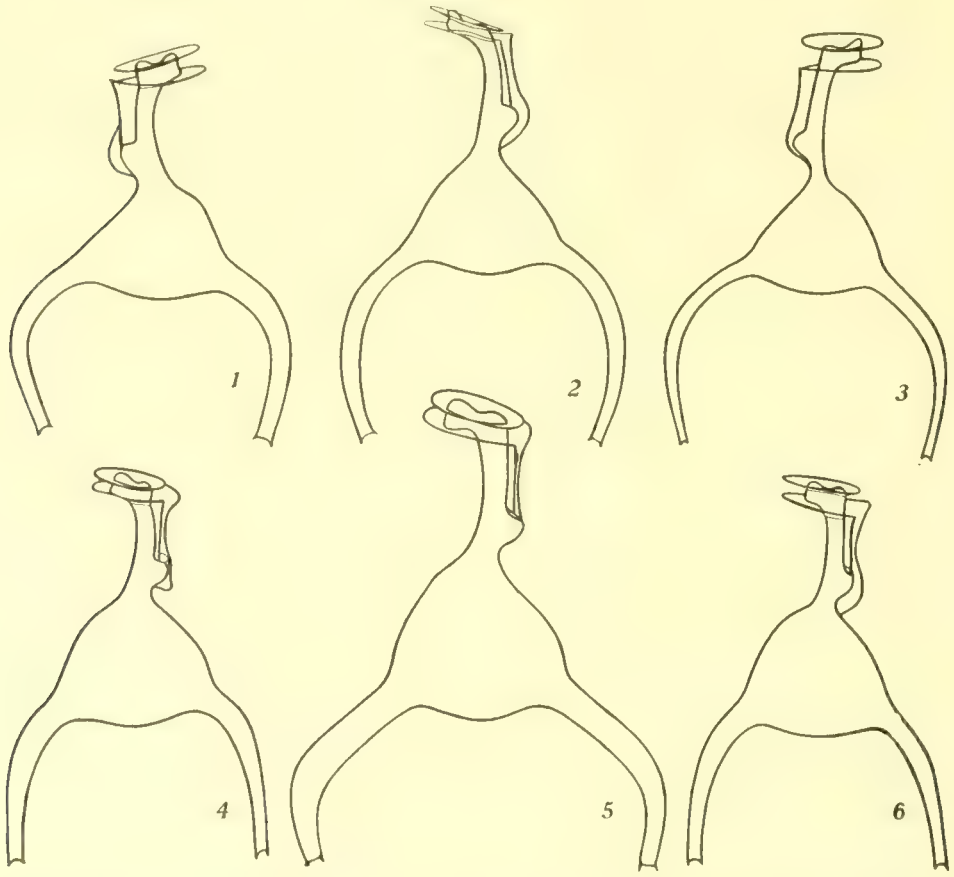

FIGURE 62.— *Triposolenia truncata* Kofoid, lateral view. 1, 3, from the left; the rest from the right. × 430. 1, 2, 3, 5, from Station 4742 (300–0 fathoms); 4, from Station 4637 (300–0 fathoms); 6, from Station 4634 (300–0 fathoms).

The midbody is subtriangular or subrotund (Jörgensen, 1923, fig. 64). Its three margins are subequal, and moderately, or rather boldly, and often nearly equally convex. The convexity of the anteroventral margin decreases toward the anterior process; sometimes this margin is almost straight. In some cases the posterior margin is somewhat longer than the anterodorsal one; and the latter is somewhat longer than the anteroventral.

The antapicals are of moderate length or comparatively short. In most cases the ventral is the longer, being 3.0 (2.7–3.4) times longer than the neck; the corresponding figures for the dorsal are 2.9 (2.7–3.2). Out of ten specimens two had subequal antapicals; and in the specimen with the greatest difference in this respect the ventral was 3.2 and the dorsal 2.9 times longer than the neck. The distance between the center of the midbody and the tip of the ventral antapical is subequal to the distance from the midpoint of the postmargin of the midbody to the anterior border of the neck. In most cases the antapicals are rather stout and taper gradually from the bases to the tips; sometimes they are widest at some distance from the bases. The ventral seems generally to be a little more slender than the dorsal; the former is, in the middle, 7–14, in most cases 8–11, the latter 6–13 (7–10) times longer than wide. The dorsoventral diameter of the tips is 0.4–0.7 that of the respective bases. The antapicals are almost symmetrical, the regions of major flexures and the tips being, respectively, approximately equidistant from the center of the midbody and in most cases also from the middle of the epitheca. The curvature is, as a rule, greatest in the middle third of the length; in this region it is, in most cases, nearly uniform, but sometimes more or less localized in a knee. In some specimens the antapicals are rather strongly curved proximally, and their distal halves are almost straight (Jörgensen, 1923, fig. 64). The distance between the tips is 3.7 (3.2–4.5) and between the outer margins at the place of greatest spread 4.3 (3.9–5.0) times longer than the neck. The distal fourth of the antapicals is deflected slightly to the left. The tips are truncate, and each tip has, on the dorsal and ventral angles, a pair of short, fine spinules. Sometimes the outer spinule alone is present and is larger than usual. No tubercles are developed.

The thecal wall is distinctly and profusely pitted (pores?), more sparingly so toward the base of the anterior process and toward the tips of the antapicals. On the neck the pits gradually widen to a rather coarse reticulum, 2–4 meshes wide on each valve.

The nucleus is small (in some cases observed) and is located posteriorly. There are a few irregular chromatophores, or numerous ellipsoidal ones gathered along the ventral margin of the midbody.

The proportions of ten specimens were measured. The length of these specimens was 130 (119–145) μ.

Dimensions: — Our specimens: Length of body, 113–145 μ (type, 131 μ). Distance from apex to midpoint of postmargin of midbody, 77–101 μ (average, 84 μ; type, 81 μ). Length of head, 6.5–10.0 μ (average, 7.7 μ; type, 7.2 μ). Length

of neck, 19.0–23.5 μ (average, 21 μ; type, 21 μ). Length of anterior process, 14–19 μ (average, 17 μ; type, 17 μ). Distance between flagellar pore and midpoint of postmargin of midbody, 49–65 μ (average, 54 μ; type, 51 μ). Distance between midpoints of bases of antapicals, 39–50 μ (average, 44 μ; type, 42 μ). Length of ventral antapical, 50–71 μ (average, 64 μ; type, 65 μ). Length of dorsal antapical, 50–69 μ (average, 61 μ; type, 61 μ). Distance between tips of antapicals, 67–105 μ (average, 78 μ; type, 67 μ). Distance between outer margins of antapicals at place of greatest spread, 78–117 μ (average, 91 μ; type, 82 μ). Jörgensen's (1923) specimens: Length of body of figured specimen, 109 μ. "Distance between points of the antapicals, 62–81 μ, midbody 34 μ high and 38–42 μ long; distance from apex to lowest (convex) boundary line of the midbody 68 μ."

Variations: — Judging by the specimens thus far observed, this species appears to be fairly uniform in proportions, except with regard to the antapicals. These vary considerably in thickness but less in length, thus giving to the organism different degrees of robustness. The spread and the shape of the antapicals and the size of the body are also subject to rather considerable variations.

Comparisons: — There can hardly be any doubt that the specimens assigned to *Triposolenia truncata* in the present paper belong to the same species as those from San Diego treated under this name by Kofoid (1906c, d). The type specimen (Kofoid, 1906c, pl. 16, fig. 5) falls within the range of variation of the specimens found in the material of the Expedition.

In the specimen figured by Jörgensen (1923, fig. 64) the midbody is more rounded and there are antapicals straighter than in our specimens. In spite of these differences, Jörgensen's determination of this form is probably correct.

Triposolenia truncata is probably the most primitive member of its genus and occupies a rather isolated position. It differs from all other species of the genus in its relatively stouter facies, the concave anterior side of its epitheca, and the very distinct structural differentiation of its thecal wall. It also is characterized by its small size, by its symmetrical and strikingly balanced antapicals, which, as a rule, have little or no geniculation, by the truncate tips of its antapicals, and by the absence of antapical tubercles. Its small size and relatively short and thick neck recall *T. depressa*. With regard to its relationship to *Amphisolenia inflata*, see the section on the subdivisions of the family (p. 336).

The rugose surface of the thecal wall of this species, which probably is a primitive character, may be interpreted as an adaptation to flotation. In other species of the genus increase in surface is acquired by a greater elongation of processes.

Synonymy: — The species was established by Kofoid (1906c) under the name

of *Triposolenia truncata*. The only other writer to treat it, viz., Jörgensen (1923), used the same name. This is the type species of the genus.

Occurrence: — The species is recorded at nineteen of the 127 stations. There are 4, 5, 0, 2, 6, and 2 stations on the six lines of the Expedition. Of these nineteen stations, two (4580, 4583) are in the California Current; five (4613, 4617, 4634, 4637, 4638) are in the Panamic Area; two (4650, 4655) are in the Peruvian Current; one (4715) is in the Galapagos Eddy; eight (4711, 4717, 4724, 4730, 4732,

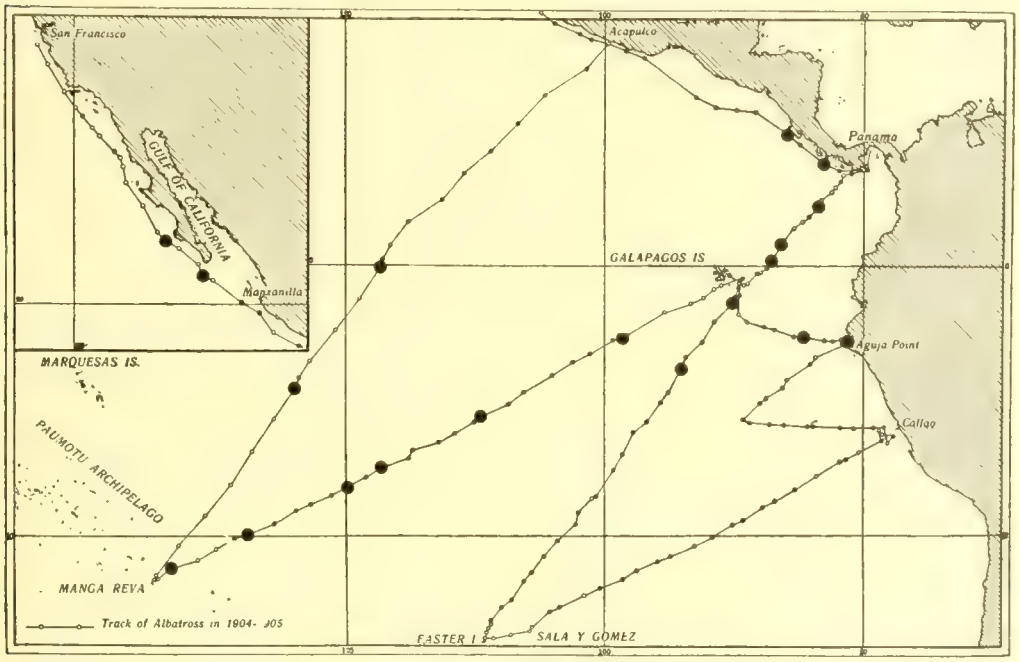

FIGURE 63.— Occurrence of *Triposolenia truncata* Kofoid. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

4737, 4739, 4740) are in the South Equatorial Drift; and one (4742) is in the South Equatorial Current. At one station (4655) the species is recorded from 400–0 fathoms. All the other records refer to catches from 300–0 fathoms.

The temperature range of these nineteen stations at the surface was 65°–83°; the average was 77.1°.

The frequency does not exceed 1%, which is recorded at three stations (4634, 4637, 4715).

The species was first recorded by Kofoid (1906c) from San Diego, California, the type locality, where it occurred sparingly in plankton from 180–0 fathoms during both winter and summer. Jörgensen (1923) found it in the Balearic Sea, east of Corsica, near Euboea, and in the Marmora Sea, "only in deeper water."

This is probably a eupelagic species of wide distribution in tropical, sub-

tropical, and warm-temperate seas. In the Eastern Pacific it has, according to the records of the Expedition, a distribution that is more in accordance with the distribution of the genus Amphisolenia than that of any other species of the genus Triposolenia. This similarity in distribution is very interesting because this species is more closely related to Amphisolenia than any other known member of its genus. According to our records, it occurs in waters of high average temperature (77.1°). Most of the record stations are in the warm Panamic Area and in the South Equatorial Drift; only two record stations are in the relatively cool Peruvian Current. Its occurrence at San Diego and in the Mediterranean shows, however, that it has a rather wide amplitude of thermal adaptation in warm-water seas. Its absence from the very warm Mexican Current may be worth mentioning.

Triposolenia depressa Kofoid

Plate 14, fig. 4–9. Figure 64, 65

Triposolenia depressa Kofoid, 1906c, p. 98, 99, 101, 102, 104, pl. 16, fig. 3, 4; 1906d, p. 118, 119, 120; 1906e, p. 130, fig. A, B.
Triposolenia sp., Steuer, 1910, fig. 106; 1911, fig. 82.
Triposolenia ambulatrix Jörgensen, 1923, p. 42, 43, fig. 63.

Diagnosis: — Head small, subspheroidal or subcylindrical. Epitheca convex. Distance between bases of antapicals 1.3–1.6 the length of neck which is 6–11 times longer than wide and almost straight. Midbody subellipsoidal or subtriangular, its longitudinal axis often foreshortened; its margins convex, the anteroventral somewhat shorter than the others and sometimes straight or even concave. Antapicals 2.1–2.8 times longer than neck, slender, subsymmetrical or more or less asymmetrical; geniculation scarcely evident; tuberculate; tips rounded, sometimes truncate and spinulate. Length, 92–122 μ.

Tropical, subtropical, and warm-temperate regions of Eastern Pacific; Marmora Sea.

Description: — The head is 0.24 (0.21–0.33) the length of the neck, subspheroidal, in most cases about as long as wide, sometimes narrower, even subcylindrical. The anterior face of the epitheca is more or less convex. The transverse furrow is flat or slightly concave. The anterior cingular list is 2.0–2.5 times wider than the transverse furrow and has, on each valve, five to eight sometimes but slightly developed ribs.

The neck is comparatively short and of moderate width. The distance between the midpoints of the bases of the antapicals is 1.4 (1.3–1.6) the length of the neck which is 6–11 (in most cases 8–10) times longer than wide. The neck is

almost straight or slightly curved dorsally, with a dorsal deflection of 21° (13°–25°) from the longitudinal axis of the body. The left sulcal list has a fission rib and, anteriorly, several other ribs.

The anterior process arises at a distance equaling or slightly exceeding half the dorsoventral width of the process, ventrally to the middle of the anterior margin of the midbody, and is deflected ventrally 28° (23°–33°) from the longitudinal axis of the body. It measures 0.52 (0.46–0.59) the length of the neck. The distance from the flagellar pore to the midpoint of the postmargin of the midbody is 1.6 (1.5–1.8) the length of the neck.

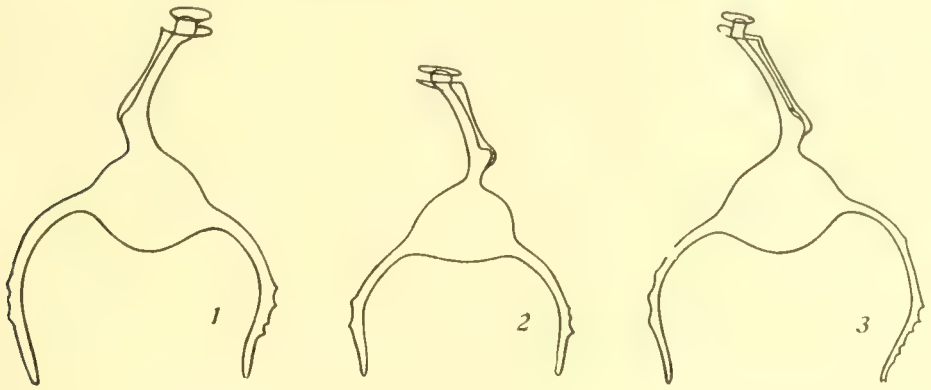

FIGURE 64.— *Triposolenia depressa* Kofoid, lateral view. 1, seen from the left; 2 and 3, from the right. × 430. 1, 2, from Station 4742 (300–0 fathoms); 3, from Station 4732 (300–0 fathoms).

The midbody is often characterized by the foreshortening of its longitudinal axis, which gives it a subellipsoidal shape with its major axis in the dorsoventral position. However, sometimes this foreshortening does not occur, and the midbody has a subtriangular shape. The three margins are more or less convex, sometimes, due to parasitic infection (?), even to such an extent as to give the midbody a subrotund shape; in a few cases the anteroventral margin is nearly straight or even slightly concave. The anteroventral margin is always somewhat shorter than the two others, due to the ventral dislocation of the anterior process; and the postmargin is always the longest.

The antapicals are of moderate lengths. In most cases the ventral is the longer, being 2.5 (2.2–2.8) times longer than the neck; the corresponding values for the dorsal are 2.2 (2.1–2.6); see the section on the comparisons of this species. Out of seven specimens two had subequal antapicals; and in the specimen with the greatest difference in this respect the ventral antapical was 2.5 and the dorsal 2.1 times longer than the neck. In three out of these seven specimens the distance between the center of the midbody and the tip of the ventral antapical was sub-

equal to the distance from the midpoint of the postmargin of the midbody to the middle of the transverse furrow. The four other specimens deviated only slightly from this type. The antapicals are of almost the same width, in most cases slender, and nearly uniform in width throughout their entire lengths. The ventral is 15–29 times longer than its average width. The two processes are fairly strongly curved; sometimes they are curved to about the same extent, sometimes either one of them is more curved than the other. The curvature is sometimes almost evenly distributed, but in most cases it is more or less localized in the proximal half of the antapical; in the latter case geniculation is scarcely evident. Distally the antapicals exhibit in most specimens a slight sigmoid flexure. The distance between the tips is 2.6 (2.3–3.1) and between the outer margins at the place of greatest spread 3.2 (3.0–3.7) times longer than the neck. In dorsoventral view the antapicals are slightly curved; sometimes they are bent to the right proximally, and to the left distally, the dorsal having more distal curvature than the ventral; sometimes the distal curvature is hardly developed at all. The tips are mostly truncate in dorsoventral view, with minute terminal spinules. In lateral view the tips are more or less rounded in most specimens, sometimes truncate. There are two to seven scattered tubercles along the outer margins of the antapicals, all of them in most cases on the distal halves of the antapicals.

The thecal wall is hyaline, apparently without structure, and with a few pores along the midventral line of the neck and in the tubercles of the antapicals.

The nucleus is large. Besides the principal pusule there is an accessory pusule. The chromatophores are few, minute, and spheroidal.

The proportions of seven specimens were measured. The length of these specimens was 105 (92–114) μ.

Dimensions: — Our specimens: Length of body, 92–122 μ (type, 108 μ). Distance from apex to midpoint of postmargin of midbody, 57–71 μ (average, 66 μ; type, 67 μ). Length of head, 5.0–7.5 μ (average, 6.0 μ; type, 7.5 μ). Length of neck, 21–28 μ (average, 25 μ; type, 23 μ). Length of anterior process, 10–15 μ (average, 13 μ; type, 13 μ). Distance between flagellar pore and midpoint of postmargin of midbody, 34–44 μ (average, 40 μ; type, 41 μ). Distance between midpoints of bases of antapicals, 31–89 μ (average, 35 μ; type, 36 μ). Length of ventral antapical, 47–74 μ (average, 62 μ; type, 63 μ). Length of dorsal antapical, 46–66 μ (average, 56 μ; type, 56 μ). Distance between tips of antapicals, 53–75 μ (average, 66 μ; type, 72 μ). Distance between outer margins of antapicals at place of greatest spread, 64–92 μ (average, 79 μ; type 77 μ). Jörgensen's (1923) specimen: Length of body, 96 μ. "Distance between points of posterior horns

89 μ, midbody 25 μ high and 38 broad, distance from apex to lower part of body 65 μ."

Variations: — The species exhibits a remarkable variability in several characters. The head is either about as long as wide, subrectangular or subrotund, or it is narrower than long, subcylindrical. In some specimens the midbody is foreshortened, its major axis being in the dorsoventral position, and its posterior margin is boldly convex and much longer than the anterior margins. In other specimens the midbody is either subrotund, or it is almost equilaterally subtriangular as in *Triposolenia bicornis* with only slightly convex posterior margin. The relative width of the neck, the curvature and spread of the antapicals, the deflection of the dorsal antapical, and the number of antapical tubercles are also rather strikingly variable characters.

Comparisons: — Some of the specimens, referred to *Triposolenia depressa* in this paper (Plate **14**, fig. 4, 5), are very similar to the type specimen of this species as drawn by Kofoid (1906c, pl. 16, fig. 3). Others (Figure 64) differ more or less strikingly from the type specimen, and their determination must be regarded as tentative. Some of these specimens (Figure 64: 2) are much smaller (about 92 μ) than *T. bicornis* (120–153 μ) and have relatively wide neck and antapicals without geniculation as in *T. depressa*. Their midbody, however, is subtriangular with only slightly convex posterior margin as in *T. bicornis*.

The specimen of this species found by Jörgensen (1923) and called *Triposolenia ambulatrix* by him differs from the type specimen especially in the shape, deflection, and relative length of the dorsal antapical. The ventral antapical is 2.4, the dorsal only 1.8 times longer than the neck. In the pronounced dorsal deflection of its dorsal antapical this specimen approaches *T. ambulatrix*.

Triposolenia depressa probably is closely related to *T. bicornis*. Jörgensen (1923, p. 42, fig. 63) even suggested that it might be but a "form" of this species. As conceived in this paper, it differs from *T. bicornis* especially in the smaller size of its body, the foreshortening of its midbody, the greater convexity of the postmargin of its midbody, the relative shortness and greater width of its neck, and the almost complete absence of geniculation in its antapicals. However, as is shown in the section on variability, the two species tend to intergrade in some of the distinctive characters.

Synonymy: — The species was established by Kofoid (1906c) under the name of *Triposolenia depressa*. The form treated by Jörgensen (1923, fig. 63) under the name *T. ambulatrix* is probably identical with *T. depressa*. Kofoid (1906e, fig. A, B) used this species to illustrate his discussion on the adaptive

nature of the asymmetry in this genus. His figures were reproduced by Steuer (1910, fig. 106; 1911, fig. 82). Kofoid did not make any reference to species in his explanation of these figures; Steuer used the designation *Triposolenia* sp.

Occurrence: — The species is recorded at twenty-two of the 127 stations. There are 2, 7, 3, 5, 4, and 1 stations on the six lines of the Expedition. Of these twenty-two stations, one (4580) is in the California Current; one (4613) is in the Panamic Area; eight (4650, 4652, 4655, 4659, 4662, 4667, 4671, 4676) are in the Peruvian Current; ten (4681, 4683, 4701, 4705, 4709, 4711, 4721, 4724, 4730,

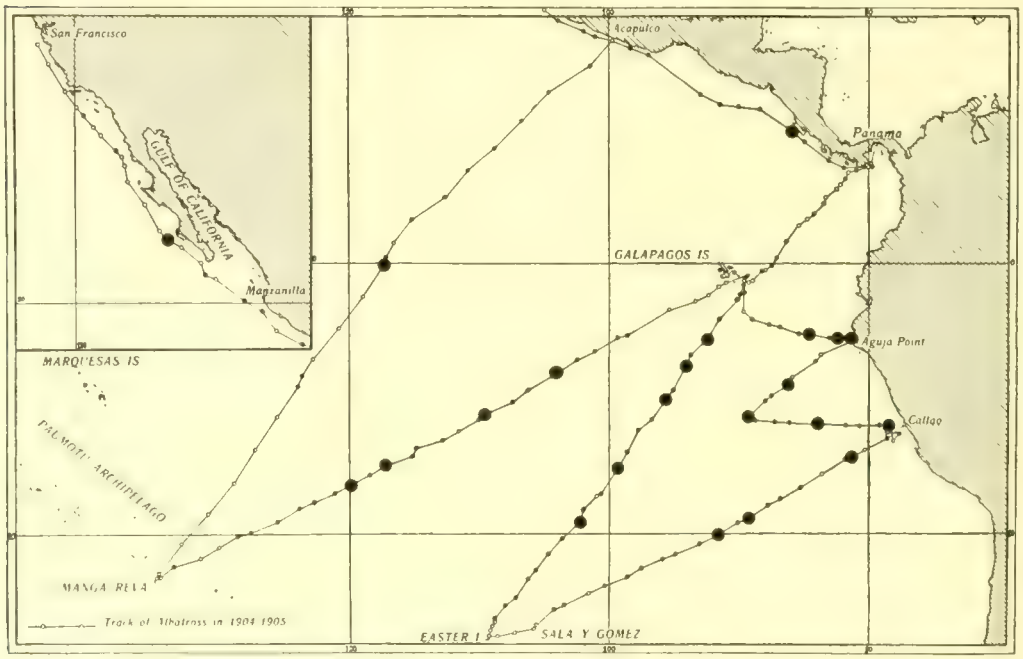

FIGURE 65.— Occurrence of *Triposolenia depressa* Kofoid. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

4732) are in the South Equatorial Drift; one (4713) is in the Galapagos Eddy; and one (4742) is in the South Equatorial Current. At one station (4652) the species is recorded from 100–0 fathoms; at two stations (4662, 4681) from 800–0 fathoms. All the other records refer to samples from 300–0 fathoms.

The temperature range of these twenty-two stations at the surface was 65°–80°; the average was 72.2°.

The frequency does not exceed 1%, which is recorded for two stations (4650, 4655).

Triposolenia depressa was first recorded by Kofoid (1906c) from San Diego, California, the type locality, where it was taken in a vertical haul from 95 fathoms.

Later it was recorded by Jörgensen (1923) from the Marmora Sea as *Triposolenia ambulatrix.*

The species probably is eupelagic and of subtropical and tropical nature, although it sometimes occurs in warm-temperate waters. In the material of the Expedition it is recorded mainly from the relatively cool Peruvian Current and from the part of the South Equatorial Drift that is under the influence of this current.

Triposolenia bicornis Kofoid

Figure 66, 67

Triposolenia bicornis Kofoid, 1906c, p. 96, 99, 101, 102, 104, 105, 107, pl. 15, fig. 1, 2, pl. 16, fig. 6; 1906d, p. 118, 119, 120. Hjort, 1911, p. 367, fig. 12:3. Gran, 1912a, p. 935, fig. 9; 1912b, fig. 233. Jörgensen, 1923, p. 41, 42, 43, fig. 62.

Diagnosis: — Head subspheroidal. Epitheca convex. Distance between bases of antapicals 1.1–1.4 the length of neck which is 9–15 times longer than wide and almost straight. Midbody subtriangular; its margins subequal or almost so and convex. Antapicals 1.8–2.4 times longer than neck, rather slender, subsymmetrical, mostly geniculate, tuberculate; tips rounded, mostly without spinules. Length, 120–153 μ.

Tropical, subtropical, and warm-temperate regions of Eastern Pacific; Mediterranean and off west coast of Portugal.

Description: — The head is 0.18 (0.15–0.20) the length of the neck and as long as wide, in some cases slightly narrower, in others slightly wider. The anterior face of the epitheca and the transverse furrow are as in *Triposolenia depressa.* The anterior cingular list is two to three times wider than the transverse furrow and has, on each valve, ten to twelve delicate ribs.

The neck is rather long and narrow. The distance between the midpoints of the bases of the antapicals is 1.2 (1.1–1.4) the length of the neck which is 9–15 times longer than wide. The neck is almost straight or slightly curved dorsally, with a dorsal deflection of 20° (15°–25°) from the longitudinal axis of the body. The left sulcal list has a fission rib.

The anterior process arises at about or slightly ventrally to the middle of the anterior margin of the midbody. It is deflected ventrally 17° (12°–21°) from the longitudinal axis of the body. It measures 0.41 (0.36–0.48) the length of the neck. The distance from the flagellar pore to the midpoint of the postmargin of the midbody is 1.4 (1.1–1.5) the length of the neck.

The midbody is subtriangular. Its margins are more or less convex, sometimes, due to parasitic infection (?), even to an extent so as to give the midbody a

subrotund shape. In some cases they are almost subequal, in others the anteroventral margin is somewhat shorter than the anterodorsal, due to the ventral dislocation of the anterior process; the postmargin is always the longest.

The antapicals are of moderate length, rather slender, subsymmetrical, and in most cases with fairly distinct knees near or somewhat distally to the middle. The ventral antapical is 2.1 (1.9–2.4), the dorsal 2.0 (1.8–2.3) times longer than the neck. Out of eight specimens one had subequal antapicals; and in the specimen with the greatest difference in this respect the ventral was 2.1, the dorsal 1.8

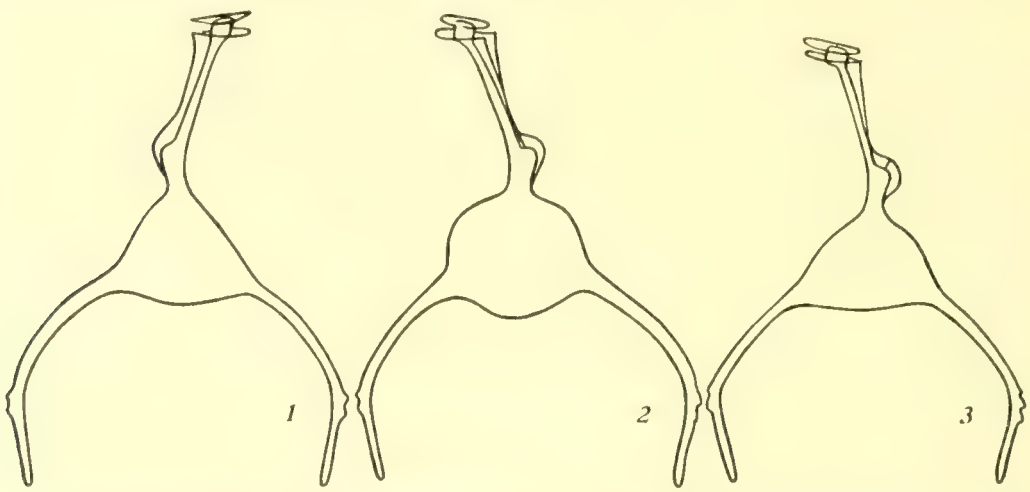

FIGURE 66.— *Triposolenia bicornis* Kofoid, lateral view. 1, seen from the left; 2 and 3, from the right. × 430. 1, from Station 4613 (300–0 fathoms); 2, from Station 4638 (300–0 fathoms); 3, from Station 4730 (300–0 fathoms).

times longer than the neck. The ventral is 16–26 times longer than its average width. The distance between the tips is 2.4 (1.9–2.9), and between the outer margins at the place of greatest spread 2.8 (2.5–3.1) times longer than the neck. The tips are rounded, mostly without spinules. For characteristics not mentioned above, see the description of the antapicals of *Triposolenia depressa* (p. 469).

The thecal wall is as in *T. depressa*.

The nucleus is large, ellipsoidal, and usually located near the posterior face of the midbody. A centrosome is found on the anterior face of the nucleus. One or two pusules are present along the ventral wall, each with efferent canal leading to the flagellar pore. The chromatophores are small, irregular, almost colorless, with superficial distribution.

The proportions of eight specimens were measured. The length of these specimens was 134 (126–141) μ.

Dimensions: — Our specimens: Length of body, 120–153 μ (type, 140 μ). In the original description (Kofoid, 1906c, p. 106) a maximum length of 185 μ is given. This high value is probably due to the fact that specimens of *Triposolenia intermedia* were included in *T. bicornis*. Distance from apex to midpoint of postmargin of midbody, 76–91 μ (average, 84 μ; type, 91 μ). Length of head, 5–7 μ (average, 6 μ; type, 7 μ). Length of neck, 30–37 μ (average, 34 μ; type, 35 μ). Length of anterior process, 12–16 μ (average, 14 μ; type, 16 μ). Distance between flagellar pore and midpoint of postmargin of midbody, 40–52 μ (average, 46 μ; type, 52 μ). Distance between midpoints of bases of antapicals, 34–44 μ (average, 40 μ; type, 44 μ). Length of ventral antapical, 65–78 μ (average, 72 μ; type, 68 μ). Length of dorsal antapical, 65–71 μ (average, 69 μ; type, 68 μ). Distance between tips of antapicals, 71–89 μ (average, 83 μ; type, 89 μ). Distance between outer margins of antapicals at place of greatest spread, 89–101 μ (average, 95 μ; type, 95 μ). Jörgensen's (1923) specimens: Length of body of figured specimen, 136 μ. "Distance between points of horns almost constantly 102 μ, the midbody (32–) 34 μ high by (38–) 43–47 μ long, distance from upper end of cell to lowest boundary line of the midbody 80–85 μ."

Variations: — As conceived in this paper, *Triposolenia bicornis* is fairly constant in structure and proportions.

Comparisons: — Most of our specimens showed a very striking resemblance to the type specimen as drawn by Kofoid (1906c, pl. 15, fig. 1). The specimen figured under the name of *Triposolenia bicornis* by Jörgensen (1923, fig. 62), also agrees closely with the type and is certainly correctly determined.

With regard to the position of this species within its genus, see *Triposolenia depressa*, *T. intermedia*, and the section on the subdivisions of the genus (pp. 471, 461).

Synonymy: — The species was established by Kofoid (1906c) and later treated by Jörgensen (1923) under the name of *Triposolenia bicornis*. Reproductions of Kofoid's (1906c) drawing of the type specimen are to be found in Hjort (1911) and in Gran (1912a, b).

Occurrence: — The species is recorded at forty-five of the 127 stations. There are 9, 11, 4, 9, 10, and 2 stations on the six lines of the Expedition. Of these forty-five stations, four (4571, 4574, 4580, 4583) are in the California Current; two (4598, 4605) are in the Mexican Current; five (4609, 4613, 4617, 4637, 4638) are in the Panamic Area; nine (4648, 4650, 4652, 4657, 4659, 4667, 4668, 4670, 4671) are in the Peruvian Current; two (4697, 4699) are in the Easter Island Eddy; two (4713, 4715) are in the Galapagos Eddy; twenty (4679, 4681, 4683, 4687, 4701,

4705, 4707, 4709, 4711, 4717, 4721, 4722, 4724, 4728, 4730, 4732, 4734, 4737, 4739, 4740) are in the South Equatorial Drift; and one (4742) is in the South Equatorial Current. At one station (4652) the species is recorded from 100–0 fathoms; at one station (4713) from 150–0 fathoms; at one station (4670) from 800–0 fathoms; at four stations (4681, 4701, 4717, 4724) from 800–0 fathoms as well as from 300–0 fathoms. All other records refer to catches from 300–0 fathoms only.

The temperature range of these forty-five stations at the surface was 66°–85°; the average was 74.4°.

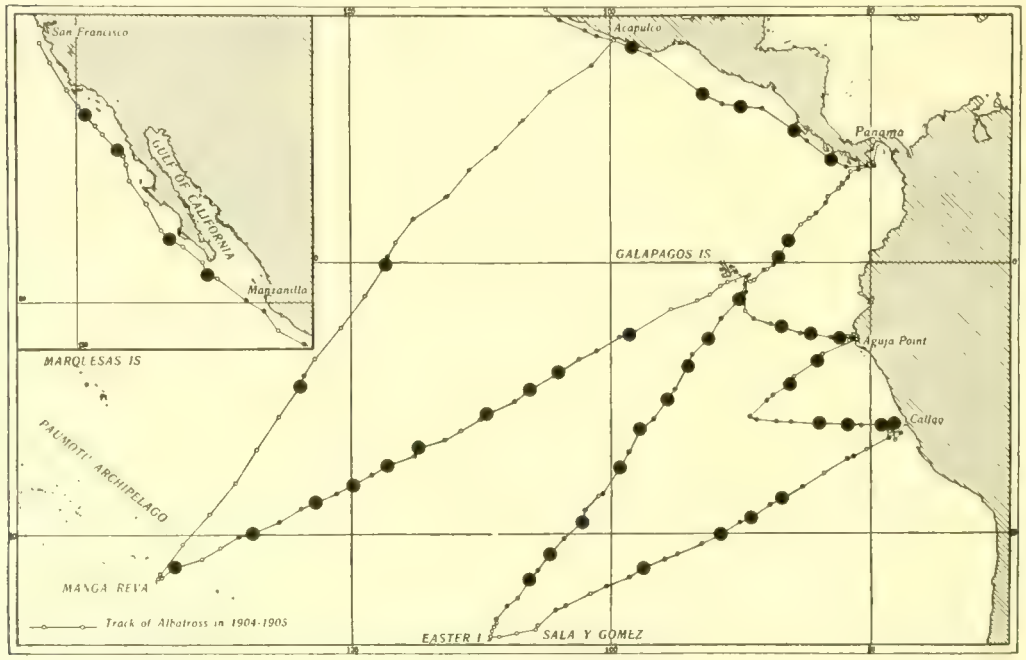

FIGURE 67.— Occurrence of *Triposolenia bicornis* Kofoid. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

At one station (4571) the frequency is 2%. At sixteen stations (4574, 4580, 4583, 4605, 4613, 4617, 4648, 4652, 4657, 4668, 4671, 4713, 4724, 4730, 4739, 4742) the frequency is 1%. At the remaining twenty-eight stations the frequency is less than 1%.

Previously the species has been taken by Kofoid (1906c) near San Diego, California, the type locality, where it frequently occurred in small numbers in vertical hauls from 135–0 fathoms, and rarely in surface catches. Jörgensen (1923) reported it as widely distributed in the Mediterranean, "especially, it would seem, between 100 and 200 m." He also found it off the southwest coast of Portugal.

This appears to be the most widely distributed and the most abundant species in the genus. It is probably eupelagic and of world-wide distribution in tropical, subtropical, and warm-temperate seas. According to the records, it is fairly evenly distributed throughout the region investigated by the Expedition.

Triposolenia intermedia, sp. nov.

Plate 14, fig. 10. Figure 60: 1, 61, 68

Diagnosis: — Head 1.3–2.0 times wider than long. Epitheca convex or flat. Distance between bases of antapicals 1.3–1.4 the length of neck, which is 7–11 times longer than wide and gently curved. Midbody subtriangular; its margins almost subequal, more or less convex. Antapicals 2.1–2.5 times longer than neck, rather slender; strongest curvature in proximal half; not geniculate; tuberculate; tips rounded, not spinulate. Wall without structure or finely striated. Length, 165–177 μ.

Tropical, subtropical, and warm-temperate regions of Eastern Pacific.

Description: — The head is 0.18 (0.16–0.24) the length of the neck and 1.3–2.0 times wider than long. The anterior face of the epitheca is slightly convex or flat. The transverse furrow is flat or slightly concave. The anterior cingular list is about twice as wide as the transverse furrow and has five to eight ribs on each valve.

The neck is rather long and of moderate width. The distance between the midpoints of the bases of the antapicals is 1.3 (1.3–1.4) the length of the neck which is 7–11 times longer than wide. The neck is gently curved dorsally, with a dorsal deflection of 20° (15°–24°) from the longitudinal axis of the body. The left sulcal list has a fission rib and several other ribs.

The anterior process arises near or somewhat ventrally to the middle of the anterior margin of the midbody; in some cases it is displaced ventrally more than its own width. It is deflected ventrally 24° (21°–29°) from the longitudinal axis of the body. It measures 0.47 (0.44–0.50) the length of the neck. The distance from the flagellar pore to the midpoint of the postmargin of the midbody is 1.6 (1.5–1.8) the length of the neck.

The midbody is subtriangular. Its three margins are convex, perhaps, on the average, slightly more so than in *Triposolenia bicornis*. The anteroventral and the anterodorsal margins are sometimes subequal, sometimes the former is somewhat shorter than the latter, due to the ventral displacement of the anterior process. The posterior margin is somewhat longer than the two others.

The antapicals are of moderate length, rather slender, almost symmetrical. The strongest curvature is, as a rule, in the proximal half of the antapical, sometimes in the middle, and not localized in a knee. There is no, or only very slight, indication of sigmoid curvature distally. The ventral antapical is 2.3 (2.2–2.5) times, and the dorsal 2.2 (2.1–2.4) times longer than the neck. Out of six specimens three had subequal antapicals; and in the specimen with the greatest difference in this respect the ventral was 2.5 times and the dorsal 2.2 times longer than the neck. In one of these specimens the distance between the center of the midbody and the tip of the ventral antapical was subequal to the distance from the midpoint of the postmargin of the midbody to the middle of the transverse furrow; in four cases the former, and in one case the latter distance was somewhat shorter than the other. The antapicals are of about the same width, and subuniform in width throughout their whole length. The ventral is 12–20 times longer than its average width. The distance between the tips is 2.9 (2.6–3.2) times, that between the outer margins at the place of greatest spread 3.1 (2.9–3.3) times longer than the neck. The tubercles and the tips of the antapicals are as in *Triposolenia bicornis*.

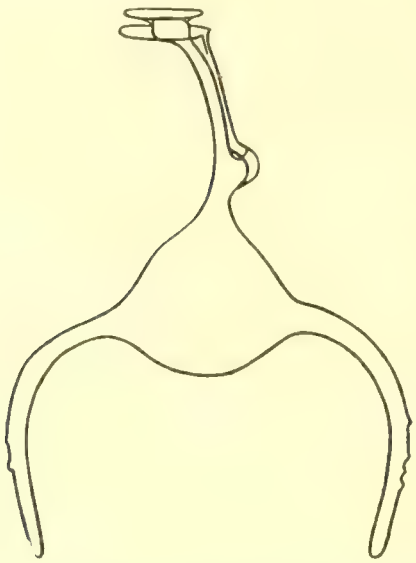

FIGURE 68. — *Triposolenia intermedia*, sp. nov., right lateral view. × 430. Station 4709 (300–0 fathoms).

The thecal wall is as in *Triposolenia depressa*, or it is characterized by a fine striation (see Plate **14**, fig. 10).

The proportions of six specimens were measured.

Dimensions: — Length of body, 165–177 μ (average, 173 μ; type, 171 μ). Distance from apex to midpoint of postmargin of midbody, 105–124 μ (average, 113 μ; type, 105 μ). Length of head, 6.5–10.0 μ (average, 7.8 μ; type, 7.0 μ). Length of neck, 40–42 μ (average, 41 μ; type, 40 μ). Length of anterior process, 18–21 μ (average, 20 μ; type, 18 μ). Distance between flagellar pore and midpoint of postmargin of midbody, 60–75 μ (average, 67 μ; type, 63 μ). Distance between midpoints of bases of antapicals, 50–56 μ (average, 54 μ; type, 50 μ). Length of ventral antapical, 92–99 μ (average, 95 μ; type, 99 μ). Length of dorsal antapical, 89–99 μ (average, 92 μ; type, 90 μ). Distance between tips of antapicals, 104–133 μ (average, 118 μ; type, 107 μ). Distance between outer margins

of antapicals at place of greatest spread, 117–137 μ (average, 128 μ; type, 117 μ).

Variations: — As conceived in this paper, *Triposolenia intermedia* is fairly uniform in structure and proportions. The most variable characters are the shape of the antapicals and of the midbody. Some specimens are rather slender, others are more or less robust.

Comparisons: — The species is established on outline drawings of six specimens. It is in size and structure intermediate between *Triposolenia bicornis* and *T. longicornis.* In the shape and proportions of the midbody and in the relative length of the antapicals it is nearer to *T. bicornis;* in the shape and relative size of the head and in the curvature of the neck it resembles *T. longicornis.* Some of our specimens of *T. intermedia* are more robust than any of the recorded specimens of *T. bicornis* and *T. longicornis.* See also the section on the subdivisions of this genus (p. 461).

Synonymy: — See the section on the dimensions of *Triposolenia bicornis* (p. 475).

Occurrence:— *Triposolenia intermedia* is recorded at four of the 127 stations. There are 3, 0, 0, 1, 0, and 0 stations on the six lines of the Expedition. Of these four stations, two (4580, the type locality, 4583) are in the California Current; one (4613) is in the Panamic Area; one (4709) is in the South Equatorial Drift. The catches in which the species was found are from 300–0 fathoms.

The temperature range of these four stations at the surface was 72°–83°; the average was 77.7°.

The frequency is less than 1%.

This appears to be a rare species. However, it is possible that several of our records of *Triposolenia bicornis* refer to *T. intermedia.* In the material of the Expedition the species is limited to catches from tropical waters of very high average temperature (77.7°).

Triposolenia longicornis Kofoid

Plate 15, fig. 1–6. Figure 69, 70

Triposolenia longicornis Kofoid, 1907a, p. 201, pl. 17, fig. 101; 1906c, p. 102; 1906d, p. 118, 119, 124.

Diagnosis: — Head 1.3–2.0 times wider than long. Epitheca flattened or convex. Distance between bases of antapicals 1.0–1.2 the length of neck, which is 10–15 times longer than wide and moderately curved. Midbody subtriangular; its three margins almost subequal, the postmargin convex, the anterior concave or convex. Antapicals 2.6–3.3 times longer than neck, slender, subsymmetrical;

geniculation scarcely evident; tuberculate; tips truncate or rounded and spinulate. Length, 210–243 μ.

Tropical and subtropical regions of Eastern Pacific.

Description: — The head is 0.16 (0.14–0.17) the length of the neck and 1.3–2.0 times wider than long. The anterior face of the epitheca is flat, seldom convex. The transverse furrow is somewhat concave, seldom flat. The anterior

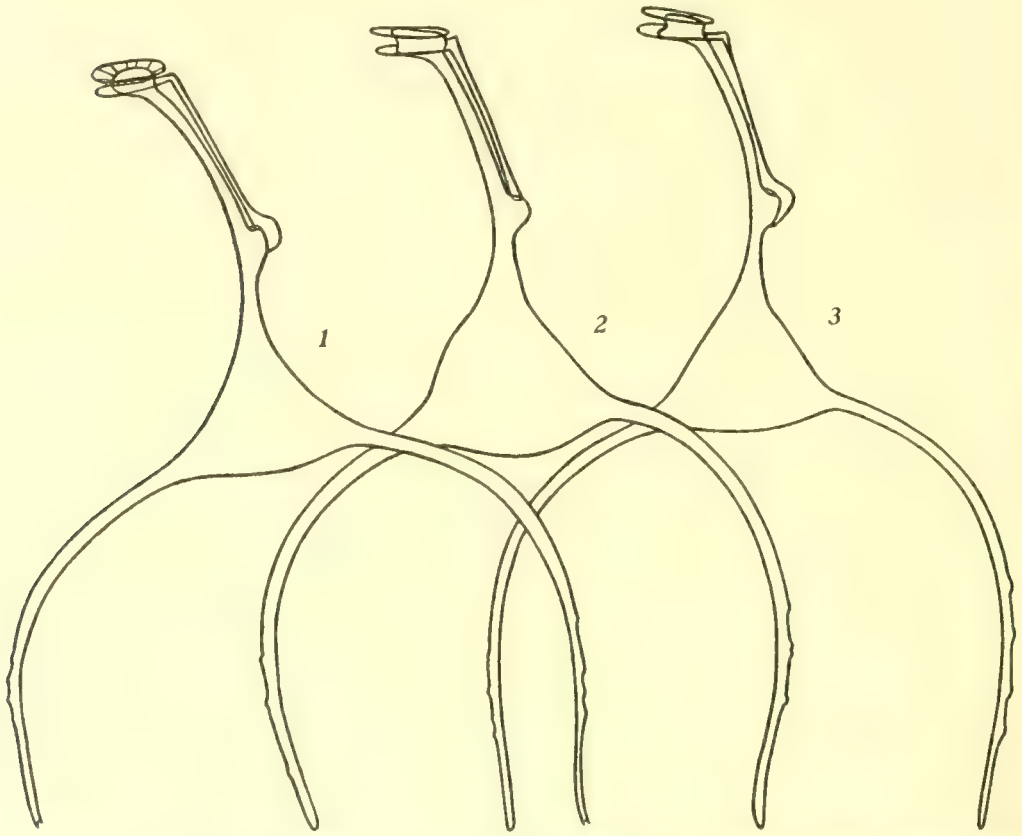

FIGURE 69.— *Triposolenia longicornis* Kofoid, right lateral view. × 430. 1, type specimen, from Station 4711 (300–0 fathoms); 2 and 3, from Station 4583 (300–0 fathoms).

cingular list is 1.5–2.0 times wider than the transverse furrow and has, on each valve, five to eight fairly well-developed ribs.

The neck is long and narrow. The distance between the midpoints of the bases of the antapicals is 1.0 (1.0–1.2) the length of the neck which is 10–15 times longer than wide. The neck is gently curved dorsally, with a dorsal deflection of 18° (14°–22°) from the longitudinal axis of the body. No fission rib has been seen, but the sulcal lists have several fine ribs anteriorly.

The anterior process arises at or near the middle of the anterior margin of the midbody and is deflected ventrally 15° (12°–19°) from the longitudinal axis of the

body. It measures 0.68 (0.61–0.70) the length of the neck. The distance from the flagellar pore to the midpoint of the postmargin of the midbody is 1.5 (1.4–1.6) the length of the neck.

The midbody is comparatively small and subtriangular. The postmargin is more or less convex and somewhat longer than the two anterior margins, which are subequal and slightly concave or convex.

The antapicals are long. In most cases the ventral is the longer, being 3.2 (3.1–3.3) times longer than the neck; the corresponding values for the dorsal are 3.0 (2.6–3.1). Out of five specimens one had subequal antapicals; and in the specimen with the greatest difference in this respect the ventral was 3.1 and the dorsal 2.6 times longer than the neck. The distance between the center of the midbody and the tip of the ventral antapical exceeds the distance from the midpoint of the postmargin of the midbody to the apex to an extent equaling the half or the whole length of the midbody. The antapicals are almost of the same width, slender, and subuniform in width throughout their entire lengths or (as in the type specimen) decidedly narrower distally than proximally. The ventral is 34–42 times longer than its average width. The antapicals are rather strongly curved, both to about the same extent. The curvature is sometimes almost evenly distributed, but in most cases it is more or less localized in the proximal half of the antapical. Only exceptionally the antapicals have a slight sigmoid flexure distally; in most cases their tips are incurved. The distance between the tips is 3.0 (2.7–3.3) and between the outer margins at the place of greatest spread 3.4 (3.2–3.5) times longer than the neck. In dorsoventral view the antapicals have a very slight sigmoid curvature, the tips being slightly curved to the left. The tips are truncate or rounded, and spinulate. There are two to five tubercles, sometimes but slightly developed, all of them on the distal halves of the antapicals.

The thecal wall, nucleus, and pusules are as in *Triposolenia depressa*.

The proportions of five specimens were measured. The length of these specimens was 232 (215–243) μ.

Dimensions: — Length of body, 210–243 μ (type, 225 μ; not 275 μ, as stated in the original description). Distance from apex to midpoint of postmargin of midbody, 118–132 μ (average, 125 μ; type, 127 μ). Length of head, 6–8 μ (average, 7.5 μ; type, 7.5 μ). Length of neck, 44–50 μ (average, 47 μ; type, 50 μ). Length of anterior process, 29–35 μ (average, 32 μ; type, 35 μ). Distance between flagellar pore and midpoint of postmargin of midbody, 69–77 μ (average, 72 μ; type, 73 μ). Distance between midpoints of bases of antapicals, 44–57 μ (average, 49 μ; type, 50 μ). Length of ventral antapical, 135–157 μ (average, 151 μ; type,

155 μ). Length of dorsal antapical, 135–148 μ (average, 140 μ; type, 129 μ). Distance between tips of antapicals, 129–163 μ (average, 142 μ; type, 163 μ). Distance between outer margins of antapicals at place of greatest spread, 151–171 μ (average, 158 μ; type, 171 μ).

Variation: — Judging by the specimens thus far examined, this species is uniform in dimensions and proportions, but the shape of its midbody is somewhat variable. The anterior margins of the midbody are either almost straight or gently concave or convex.

Comparisons: — The description given above is based on the type material.

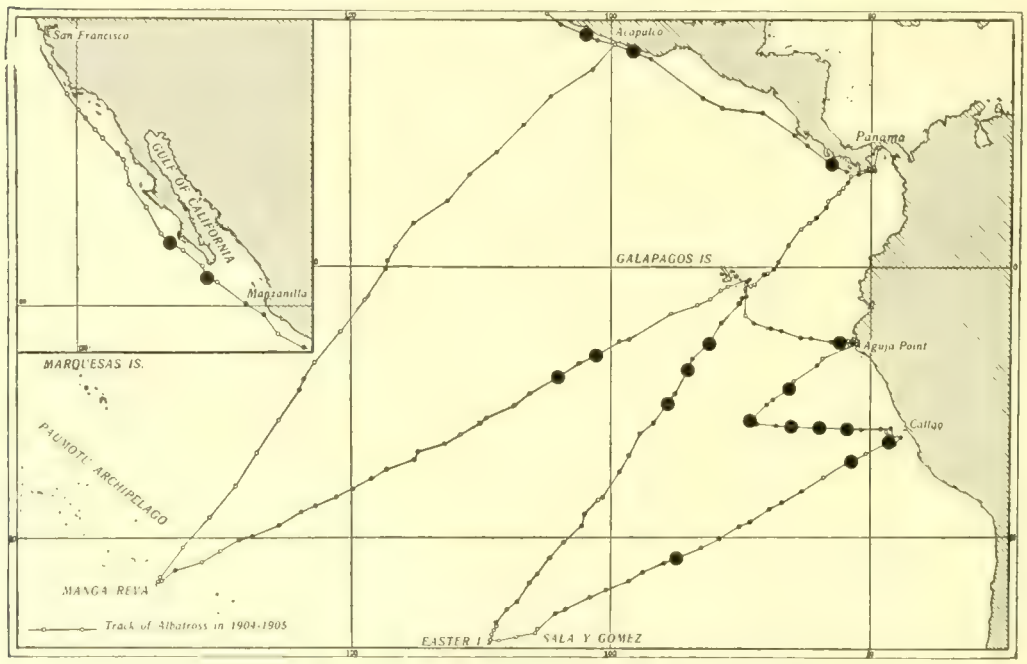

FIGURE 70. — Occurrence of *Triposolenia longicornis* Kofoid. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

Triposolenia longicornis probably is very closely related to *T. intermedia*, which in size and structure is intermediate between this species and *T. bicornis* (see *T. intermedia*, the section on comparisons, p. 479). Another close relative of this species probably is *T. fatula*, which it resembles in its long and narrow processes and in having a midbody with straight or but slightly concave or convex margins. It differs from this species especially in its relatively larger head, in the more pronounced dorsal deflection of its neck, and in not having the longitudinal axis of the midbody foreshortened. See also the section on the subdivisions of the genus (p. 461).

The species exhibits a very high degree of adaptation to flotation in its very

long and slender processes and in the relatively small size of its midbody. Its processes are longer relatively than in any other species of this genus.

Occurrence: — The species is recorded at nineteen of the 127 stations. There are 5, 6, 3, 3, 2, and 0 stations on the six lines of the Expedition. Of these nineteen stations, two (4580, 4583) are in the California Current; two (4594, 4598) are in the Mexican Current; one (4617) is in the Panamic Area; eight (4652, 4659, 4662, 4665, 4667, 4668, 4675, 4676) are in the Peruvian Current; one (4713) is in the Galapagos Eddy; five (4685, 4709, 4711, 4719, 4721) are in the South Equatorial Drift. At one station (4652) the species is recorded from 100–0 fathoms and at one (4662) from 800–0 fathoms. All the other records refer to samples from 300–0 fathoms.

The temperature range of these nineteen stations at the surface was 66°–84°; the average was 72.2°.

The frequency never exceeds 1%, which is recorded at three stations (4617, 4675, 4713).

The species was first recorded by Kofoid (1907a) from Stations 4583 (not 4385 as originally stated) and 4711 of the Expedition. Of these two stations the last mentioned is the type locality.

The frequent occurrence of this species in the relatively cool Peruvian Current is remarkable. In this current the species is recorded at eight (30.8%) out of the twenty-six stations; in the South Equatorial Drift at only five (10.9%) out of the forty-six stations. Moreover, all the record stations in the South Equatorial Drift are in the eastern part of this region, which is under the influence of the Peruvian Current.

Triposolenia fatula Kofoid

Figure 71

Triposolenia fatula Kofoid, 1907a, p. 202, pl. 17, fig. 102; 1906c, p. 96, 102; 1906d, p. 119.

Diagnosis: — Head subspheroidal. Epitheca convex. Distance between bases of antapicals 1.4 the length of neck which is 14 times longer than wide and constricted anteriorly. Midbody subtriangular; its longitudinal axis foreshortened; its margins straight or very slightly convex or concave, the anteroventral one shortest. Antapicals 3.3–3.4 times longer than neck, slender; curvature as in *Triposolenia ambulatrix* but less asymmetrical; tuberculate; tips truncate and spinulate. Length, 175 μ.

Tropical and subtropical regions of Eastern Pacific.

Description: — The head is 0.20 the length of the neck, subspheroidal, about

as long as wide. The anterior face of the epitheca is convex. The transverse furrow is flat or slightly concave. The anterior cingular list is 2.0–2.5 times wider than the transverse furrow and has, on each valve, five to eight well-developed ribs.

The neck is long, narrow, and suberect. The distance between the midpoints of the bases of the antapicals is 1.4 the length of the neck which is 14 times longer

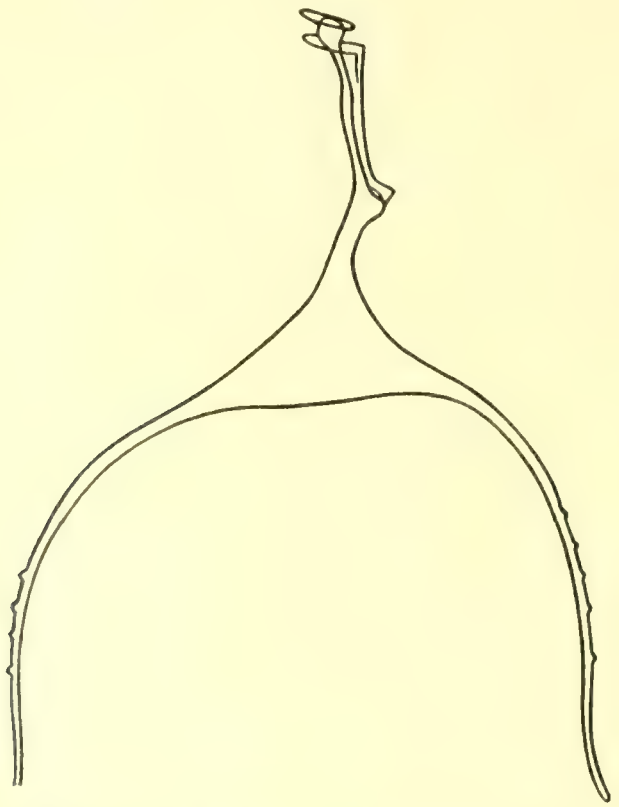

FIGURE 71.— *Triposolenia fatula* Kofoid, right lateral view of type specimen. × 430. Station 4587 (300–0 fathoms).

than wide. Anteriorly, near the head, the neck is constricted. It is almost straight, with a dorsal deflection of 7° from the longitudinal axis of the body. The left sulcal list has a fission rib and, anteriorly, several well-developed ribs.

The anterior process arises at a distance equaling half the dorsoventral width of the process, ventrally to the middle of the anterior margin of the midbody, and is deflected ventrally 27° from the longitudinal axis of the body. Its length almost equals that of the midbody and measures 0.73 the length of the neck. The distance from the flagellar pore to the midpoint of the postmargin of the midbody is 1.5 the length of the neck.

The midbody is subtriangular, with foreshortened longitudinal axis and with

its major axis in the dorsoventral position. The three margins are almost straight. The postmargin is very slightly convex, the two anterior ones are straight or very slightly concave or convex. The posterior margin is longer and the anteroventral shorter than the anterodorsal. The shortness of the anteroventral margin is due to the ventral dislocation of the anterior process.

The antapicals are long; the ventral is 3.4 and the dorsal 3.3 times the length of the neck. The distance between the center of the midbody and the tip of the ventral antapical exceeds the distance from the midpoint of the postmargin of the midbody to the apex to an extent somewhat exceeding the length of the midbody. The antapicals are of about the same width, slender, subuniform in width throughout their entire length. The ventral is about 50 times longer than its average width. They are fairly strongly curved, somewhat asymmetrical; the dorsal does not converge or show a sigmoid flexure distally, as does the ventral; the curvature is not localized in a knee but fairly evenly distributed. The distance between the tips (*i.e.*, the distance between the outer margins at the place of greatest spread) is 4.0 times longer than the neck. In dorsoventral view, the dorsal antapical bends, distally, to the left; so does the ventral one but only very slightly and at the very end. The tips are truncate and minutely spinulate.

The thecal wall is as in *Triposolenia depressa.*

The cytoplasm contains a number of double-contoured plasmosomes. A large sack-shaped pusule is located in the anteroventral part of the midbody adjacent to the nucleus. From it a slender canal runs to the flagellar pore, expanding into a small vesicle near the pore. The nucleus is ellipsoidal and lies in a subcentral position.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 175 μ (not 190 μ, as stated in Kofoid, 1907a). Distance from apex to midpoint of postmargin of midbody, 87 μ. Length of head, 6.5 μ. Length of neck, 33 μ. Length of anterior process, 24 μ. Distance between flagellar pore and midpoint of postmargin of midbody, 49 μ. Distance between midpoints of bases of antapicals, 47 μ. Length of ventral antapical, 112 μ. Length of dorsal antapical, 110 μ. Distance between tips of antapicals (distance between outer margins of antapicals at place of greatest spread), 132 μ.

Comparisons: — The description given above is based on outline drawings of the type specimen.

Triposolenia fatula combines structural features of *T. longicornis* and *T. ambulatrix.* It resembles *T. longicornis* in its long and narrow processes and in having a midbody with straight or but slightly concave or convex margins. It

differs from this species in its relatively smaller head, its more erect neck, and in the foreshortened longitudinal axis of its midbody. It resembles *T. ambulatrix* in the foreshortening of the longitudinal axis of its midbody and in the asymmetry of its antapicals. It differs from this species in the almost straight margins of its midbody, its relatively longer and more slender processes, and its less pronounced asymmetry.

Occurrence: — The species is recorded at only three of the 127 stations. These three stations (4587, 4594, 4598) are on the first line of the Expedition and in the Mexican Current. The catches in which the species was found are from 300–0 fathoms.

The temperature range of these three stations at the surface was 82°–84°; the average was 83.3°.

At Station 4598 the frequency is 1%, at the remaining stations less.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4587 of the Expedition, which thus is the type locality.

Judging by the available records, it appears to be one of the rarest of the species of the genus and restricted to waters of very high temperatures. Its adaptation to the low viscosity of its recorded habitat is suggested by the extreme elongation and marked slenderness of its processes, its relatively broad cingular lists, and its large pusule.

Triposolenia ambulatrix Kofoid

Plate **14**, fig. 11–14. Figure 60: 3, 72

Triposolenia ambulatrix Kofoid, 1907a, p. 203, pl. 4, fig. 24; 1906c, p. 96, 102; 1906d, p. 118, 119, 124.
non *Triposolenia ambulatrix* Jörgensen, 1923, p. 42, 43, fig. 63.

Diagnosis: — Head subspheroidal or subcylindrical. Epitheca convex. Distance between bases of antapicals 1.5–1.7 the length of neck which is 12–17 times longer than wide and almost straight or gently curved. Midbody subtriangular or subellipsoidal, its longitudinal axis foreshortened; with convex margins. Antapicals, 2.2–2.6 times longer than neck, slender, decidedly asymmetrical; deflected dorsally, more so than in other known species; not geniculate; with or without tubercles; tips rounded or truncate and spinulate. Length, 120–159 μ.

Tropical and subtropical regions of Eastern Pacific.

Description: — The head is 0.19 the length of the neck. Its structure is about the same as in *Triposolenia depressa*. The neck is rather long and narrow. The distance between the midpoints of the bases of the antapicals is 1.5 (1.5–1.7) the

length of the neck which is 12–17 times longer than wide. The neck is almost straight or gently curved dorsally, with a dorsal deflection of 5° (0°–8°) from the longitudinal axis of the body. The ribs of the sulcal lists are very weak, scarcely noticeable; the fission rib was found in one specimen.

The anterior process arises ventrally to the middle of the anterior margin of the midbody; its distance from the middle equals or is somewhat greater or smaller than half its dorsoventral width. It is deflected ventrally 22° (17°–30°) from the longitudinal axis of the body. It measures 0.57 (0.56–0.58) the length of the neck. The distance from the flagellar pore to the midpoint of the postmargin of the midbody is 1.6 (1.4–1.7) the length of the neck.

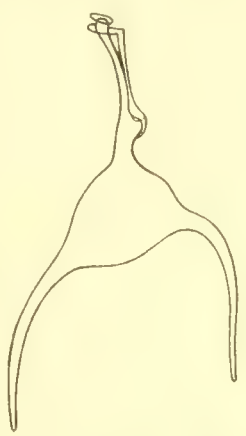

FIGURE 72.— *Tripolenia ambulatrix* Kofoid, right lateral view. × 430. Station 4598 (300–0 fathoms).

The midbody is subtriangular or subellipsoidal with foreshortened longitudinal axis and with its major axis in the dorsoventral position. Its three margins are more or less convex. The anteroventral margin is always somewhat shorter than the two others, due to the ventral dislocation of the anterior process; and the postmargin is always the longest.

The antapicals are pronouncedly asymmetrical and of moderate lengths. In one case the ventral was 2.6, the dorsal 2.3 times longer than the neck; in two other cases the corresponding figures were 2.4 and 2.5, and 2.3 and 2.2. In two out of three specimens the distance between the center of the midbody and the tip of the ventral antapical was subequal to the distance from the middle of the postmargin of the midbody to the apex; in the third case the latter distance was somewhat longer. The antapicals are of about the same width and taper gradually from the bases to the tips. The ventral is, in the middle, 19–22 times longer than wide. The dorsoventral diameter of the tips is 0.25–0.50 that of the bases. The ventral antapical is abruptly deflected posterodorsally, and has a more or less pronounced sigmoid curvature, its tip being deflected ventrally. The dorsal is not bent so as to form a balanced horn, in reversed symmetry, as in most of the other species of this genus, but is thrown posterodorsally with a moderate dorsal convexity; its tip is sometimes deflected dorsally, which gives it a sigmoid shape. The distance between the tips (*i. e.*, the distance between the outer margins at the place of greatest spread) is 3.2 (2.7–3.5) times longer than the neck. In dorsoventral view the antapicals are somewhat curved, the tip of the dorsal being deflected to the left, that of the ventral to the right. The tip of the ventral is rounded

or more or less acute, that of the dorsal truncate and furnished with two minute spinules. The tubercles are very slightly developed and few in number; sometimes they are absent.

The thecal wall and the nucleus are as in *Triposolenia depressa*. The cytoplasm of the type specimen was crowded with numerous highly refractive double-contoured bodies.

The proportions of three specimens were measured. The length of these specimens was 146 (120–159) μ.

Dimensions: — Length of body, 120–159 μ (average, 146 μ; type, 158 μ). Distance from apex to midpoint of postmargin of midbody, 77–96 μ (average, 88 μ; type, 96 μ). Length of head, 5.0–6.5 μ (average, 6.0 μ; type, 6.5 μ). Length of neck, 26–35 μ (average, 32 μ; type, 34 μ). Length of anterior process, 15–20 μ (average, 18 μ; type, 19 μ). Distance between flagellar pore and midpoint of postmargin of midbody, 45–55 μ (average, 50 μ; type, 55 μ). Distance between midpoints of bases of antapicals, 39–58 μ (average, 49 μ; type, 58 μ). Length of ventral antapical, 59–90 μ (average, 77 μ; type, 90 μ). Length of dorsal antapical, 57–88 μ (average, 74 μ; type, 77 μ). Distance between tips of antapicals (distance between outer margins of the latter at place of greatest spread), 70–120 μ (average 101 μ; type, 120 μ).

Variations: — The species is rather constant in the few specimens thus far examined. The midbody varies in the degree of convexity of the anterior margins and in the degree of foreshortening. The decided convexity of the anterior margins of the midbody in the type specimen might be correlated with the fact that the midbody of this specimen was crowded with a great number of highly refractive double-contoured bodies. The degree of dorsal deflection of the antapicals is also variable.

Comparisons: — The description given above is based on the type material.

This is the most asymmetrical of the species of this genus. It has the most marked contrast between the dorsal and the ventral antapicals. The dorsal antapical is deflected dorsally to such a degree that its balance with the ventral one, so apparent in other species of this genus, is destroyed.

With regard to the relationships between this species and the other species of this genus, see *Triposolenia fatula* and the section on the subdivisions of this genus (p. 461).

Synonymy: — The species was established by Kofoid (1907a) under the name of *Triposolenia ambulatrix*. The form figured by Jörgensen (1923, fig. 63) as *T. ambulatrix* seems to be *T. depressa* Kofoid.

Occurrence: — The species is recorded at four only of the 127 stations. There are 2, 0, 0, 2, 0, and 0 stations on the six lines of the Expedition. Of these four stations, two (4587, 4598) are in the Mexican Current; one (4711) is in the South Equatorial Drift; one (4713) is in the Galapagos Eddy. All the samples in which the species was found are from 300–0 fathoms.

The temperature of these four stations at the surface was 73°–84°; the average was 78.5°.

The frequency is less than 1% except at Station 4598, where it is 1%.

The species was first recorded by Kofoid (1907a) from Station 4711 of the Expedition, which thus is the type locality.

It is eupelagic and appears to be one of the rarer species of the genus. In the material of the Expedition it is limited to catches from tropical waters.

Subgenus 2. Ramiciformia Kofoid. — Of the two species that belong to this subgenus only one, *Triposolenia ramiciformis*, has been found in the material of the Expedition.

Triposolenia ramiciformis Kofoid

Figure 60: 2, 73, 74

Triposolenia ramiciformis Kofoid, 1906c, p. 94, 99, 101, 102, 106, 107, 108, 109, 110, pl. 17, fig. 7; 1906d, p. 118, 119, 120.

Diagnosis: — Head small, capitate. Epitheca convex. Distance between bases of antapicals 0.77–0.97 the length of neck which is 11–17 times longer than wide and almost straight. Midbody pendent, subellipsoidal. Antapicals 2.6–3.4 times longer than neck, slender, subsymmetrical or more or less asymmetrical, geniculate, tuberculate; tips rounded. Length, 144–169 μ.

Tropical, subtropical, and warm-temperate regions of Eastern Pacific.

Description: — The head is 0.17 (0.15–0.19) the length of the neck, capitate, in most cases about as long as wide. The anterior face of the epitheca is more or less convex. The transverse furrow is flat or slightly concave or convex. The anterior cingular list is 1.5–2.5 times wider than the transverse furrow and has many fine ribs.

The neck is rather long and narrow. The distance between the midpoints of the bases of the antapicals is 0.89 (0.77–0.97) the length of the neck which is 11–17 times longer than wide. The neck is almost straight, with a dorsal deflection of 15° (5°–21°) from the longitudinal axis of the body. The left sulcal list has a fission rib.

The anterior process arises from the midbody at the base of the ventral

antapical. It is deflected ventrally 29° (22°–38°) from the longitudinal axis of the body. It measures 0.47 (0.41–0.54) the length of the neck. The distance from the flagellar pore to the hindmost point of the postmargin of the midbody is 1.7 (1.6–1.9) the length of the neck.

The midbody is pendent, sack-shaped, and generally broadly rounded posteriorly; usually it tapers but little near its posterior end, but several specimens have been seen in which it tapers gradually from the bases of the antapicals to a

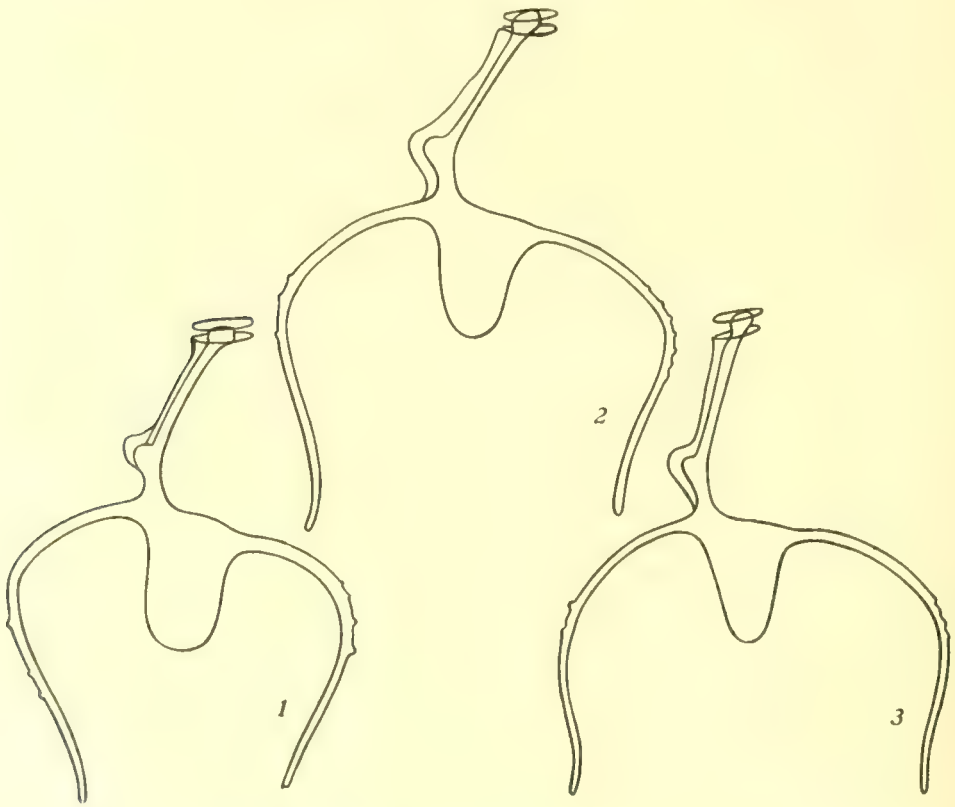

FIGURE 73.— *Triposolenia ramiciformis* Kofoid, left lateral view. × 430. 1, from Station 4681 (300–0 fathoms); 2, 3, from Station 4613 (300–0 fathoms).

rather narrowly rounded posterior end. The ventral antapical and the anterior process arise together from the anteroventral angle of the midbody and the dorsal antapical from the anterodorsal angle. The anterior edge of the midbody, between the anterior process and the dorsal antapical, is almost straight or slightly convex or concave.

The antapicals are rather long. In most cases the ventral is the longer, being 3.2 (2.7–3.4) times longer than the neck; the corresponding figures for the dorsal are 2.9 (2.6–3.1). Out of twelve specimens one had the ventral shorter than the

dorsal, the former being 2.7, the latter 2.9 times longer than the neck. In the specimen with the greatest difference in this respect the ventral was 3.3, the dorsal 2.8 times longer than the neck. The antapicals are of almost the same width, slender, and subuniform in width throughout their entire lengths. The ventral is 30–40 times longer than its average width. They are strongly curved. Sometimes they are curved to about the same extent, sometimes either one of them is more curved than the other. The curvature is sometimes almost evenly distributed, but in most cases there is a distinct knee near or somewhat proximally to the middle of the antapical. Distally the antapicals exhibit in most cases a more or less developed sigmoid flexure. The distance between the tips is 2.3 (1.8–2.8) and between the outer margins at the place of greatest spread 3.1 (2.9–3.2) times longer than the neck. In the region of the major flexure and behind it, each antapical has, on its outer surface, two to six tubercles. The tips are rounded or more or less bluntly pointed.

The thecal wall is as in *Triposolenia depressa*.

The nucleus is lenticular in shape, bilaterally compressed, and lies in the posterior part of the midbody. The chromatophores are few, irregular in form, and yellowish green.

The proportions of twelve specimens were measured. The length of these specimens was 154 (144–169) μ.

Dimensions: — Length of body, 144–169 μ (average, 154 μ; type, 152 μ). Distance from apex to hindmost point of postmargin of midbody, 100–111 μ (average, 105 μ; type, 107 μ). Length of head, 6–7 μ (average, 6.5 μ; type, 6.0 μ). Length of neck, 35–42 μ (average, 38 μ; type, 40 μ). Length of anterior process, 15–22 μ (average, 18 μ; type, 17 μ). Distance from flagellar pore to hindmost point of postmargin of midbody, 61–70 μ (average, 65 μ; type, 65 μ). Distance between midpoints of bases of antapicals, 30–36 μ (average, 34 μ; type, 36 μ). Length of ventral antapical, 106–133 μ (average, 121 μ; type, 119 μ). Length of dorsal antapical, 103–126 μ (average, 110 μ; type, 108 μ). Distance between tips of antapicals, 64–114 μ (average, 89 μ; type, 96 μ). Distance between outer margins of antapicals at place of greatest spread, 110–130 μ (average, 119 μ; type, 117 μ).

Variations: — The species is strikingly variable with regard to the shape of the midbody. In some specimens the midbody tapers uniformly to a blunt posterior tip, while in others its dorsal and ventral margins are subparallel, and its posterior end is broadly rounded. The antapicals vary in degree of sigmoid flexure, in the distance between the tips, and in the amount of tuberculation. There

are some differences in the amount of lateral displacement of the origin of the anterior process and in the obliquity of the neck.

Comparisons: — Most of the specimens assigned to *Triposolenia ramiciformis* in this paper agree very closely with the type specimen of this species as drawn by Kofoid (1906c, pl. 17, fig. 7).

The species differs from *Triposolenia exilis*, the only other species of this subgenus, in the greater obliquity of the neck, in the greater width of the anterior part of the midbody, and in the less immediate posterior deflection of the ant-

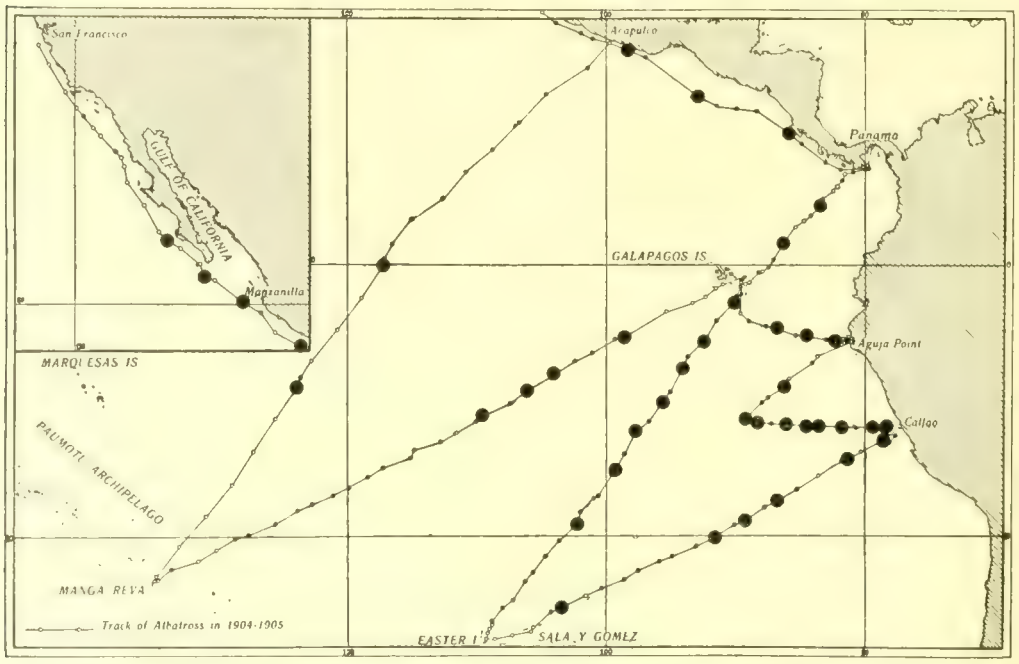

FIGURE 74.— Occurrence of *Triposolenia ramiciformis* Kofoid. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

apicals. It is probably better adapted to flotation than *T. exilis*. The tuberculations on the antapicals are farther in front in the subgenus Ramiciformia than in the subgenus Triposolenia.

Occurrence: — The species is recorded at forty of the 127 stations. There are 7, 14, 6, 7, 4, and 2 stations on the six lines of the Expedition. Of these forty stations, two (4580, 4583) are in the California Current; four (4587, 4590, 4598, 4605) are in the Mexican Current; three (4613, 4634, 4637) are in the Panamic Area; fourteen (4648, 4650, 4652, 4659, 4662, 4663, 4665, 4666, 4667, 4668, 4670, 4671, 4675, 4676) are in the Peruvian Current; one (4691) is in the Easter Island Eddy; two (4713, 4715) are in the Galapagos Eddy; thirteen (4679, 4681, 4683,

4701, 4705, 4707, 4709, 4711, 4717, 4721, 4722, 4724, 4740) are in the South Equatorial Drift; one (4742) is in the South Equatorial Current. At one station (4652) the species is recorded from 100–0 fathoms, at three stations (4662, 4670, 4715) from 800–0 fathoms, and at one station (4681) from both 800–0 fathoms and 300–0 fathoms. All the other records refer to catches from 300–0 fathoms only.

The temperature range of these forty stations at the surface was 66°–85°; the average was 73.4°.

At two stations (4648, 4663) a frequency of 2% is recorded. At ten stations (4598, 4650, 4659, 4552, 4666, 4668, 4671, 4701, 4715, 4742) a frequency of 1% was found. At the remaining stations the frequency is less than 1%.

Previously the species has been taken by Kofoid (1906c) off San Diego, California, the type locality, where it occurred in catches from 100 fathoms.

This is one of the two most widely distributed and abundant species of the genus in the region investigated by the Expedition, standing second to *Triposolenia bicornis* with forty-five record stations. It appears to be more concentrated than any other species of this genus in the Peruvian Current and in the eastern part of the South Equatorial Drift, which is under the influence of this current.

3. ORNITHOCERCIDAE, fam. nov.

Diagnosis: — Body of diverse shapes, usually about as long as deep or more or less decidedly deeper than long. Epitheca low, more or less disk-like; its depth 0.07–0.88 the depth of hypotheca. Transverse furrow, as a rule, wide and decidedly wider dorsally than ventrally; its dorsal width 0.33–0.77 the greatest depth of body. Cingular lists large, inclined anteriorly, funnel-shaped; dorsal width, 0.30–2.00 the depth of body. Usually with phaeosomes in girdle. Length of body, 13.3–88.7 μ.

Marine and eupelagic, widely distributed in tropical, subtropical, and warm-temperate waters.

Subdivisions. Relationships among the Genera

The species of the family Ornithocercidae have in the present paper been assigned to one of three genera, viz., Ornithocercus, Parahistioneis, and Histioneis. Of these genera, Ornithocercus and Histioneis were established by Stein (1883), while Parahistioneis is new. Following the suggestion of Murray and Whitting (1899), a fairly great number of investigators rejected Stein's (1883) genus Ornithocercus and referred all the known species, among which were representatives of all the three genera mentioned above, to one single genus, Histioneis (see the historical section of Ornithocercus, p. 509). We are not able to accept this decision, which was caused by the discovery of *Histioneis* (= *Parahistioneis*) *francescae* and *H.* (= *Parahistioneis*) *para*, since Ornithocercus and Histioneis are structurally very distinct and evidently represent two evolutionary lines embodying very different structural developments. For instance, in Ornithocercus (*1*) the anterior cingular list does not become stalked; (*2*) the posterior cingular list has no submarginal cross-rib but a great number of radial ribs; and (*3*) the left sulcal list has usually more than one main rib behind the fission rib. In Histioneis, on the other hand, (*1*) the anterior cingular list is stalked in all but one of the twenty-eight known species; (*2*) the posterior cingular list has a submarginal cross-rib but only two pairs of radial ribs, viz., those next to the sagittal suture; and (*3*) the left sulcal list has never more than one main rib behind the fission rib. Parahistioneis occupies in several respects a position intermediate between Ornithocercus and Histioneis. For example, it agrees with Ornithocercus in not having any submarginal cross-rib in the posterior cingular list, and all but one

of its species resemble Histioneis in having a single main rib in the left sulcal list behind the fission rib. In regard to the stalking of the anterior cingular list and to the radial ribs of the posterior cingular list, some of the members of Parahistioneis exhibit tendencies inherent in Histioneis, while others approach Ornithocercus. A further generic subdivision of this family will probably be desirable and feasible after a thorough reëxamination of the right sulcal list which is now unknown in most of the species. Parahistioneis includes quite heterogeneous elements, and at least one member of Ornithocercus, viz., *O. formosus*, is likely to have its generic allocation changed.

Lindemann (1924, p. 7) suggested that Ornithocercus, "die Krone aller Peridineen," evolved from Histioneis. This, however, can hardly be the case for the following reasons: — (*1*) the primitive species of Ornithocercus (*O. splendidus*) have a deeper epitheca than Histioneis and the width of their transverse furrow is subuniform throughout; (*2*) even the most primitive members of Histioneis, viz., *H. costata* and *H. paulseni*, have the posterior cingular list of a much more advanced type than the one characteristic of Ornithocercus. In other words, in these *three* fundamental respects Ornithocercus is more primitive than Histioneis. Neither can we derive Histioneis from Ornithocercus. The former genus is in some respects, especially in the structure of the left sulcal list, more primitive than the latter. In considering the relationship between these two genera, the structure of the right sulcal list should also be taken into account.

It seems to be most in conformity with known facts to assume that the three genera of this family evolved independently from a common ancestor approaching the Dinophysis type and embodying the following characteristics: — (*1*) the body was subrotund in lateral outline; (*2*) the transverse furrow was located anteriorly and of subuniform width throughout; (*3*) the anterior cingular list was wide and funnel-shaped but not stalked and furnished with a great number of radial ribs; (*4*) the posterior cingular list was fairly wide, inclined anteriorly, open ventrally, and had a rather great number of radial ribs but no submarginal rib; (*5*) the right sulcal list was fairly small and its ventral edge free; (*6*) the left sulcal list ended on the posteroventral side of the body, was angular posteroventrally, and had but one main rib behind the fission rib; (*7*) the thecal wall was areolate or finely reticulate. From this ancestral type the present genera evolved partly by progressive, partly by retrogressive evolutionary processes.

Distribution: — The three genera of Ornithocercidae are exclusively marine, eupelagic, and widely distributed in tropical, subtropical, and warm-temperate waters. Most of the species have been found only in the warmest regions of the

seas. While some of the species of Ornithocercus occasionally may be found in large numbers, most members appear to be exceedingly rare. The optimum habitat of most species is the deeper levels of photosynthesis, but some species of Ornithocercus are rather frequent in surface waters.

Key to the Genera

1. Posterior cingular list with submarginal cross-rib ..... *Histioneis* Stein (1883).
1. Posterior cingular list without submarginal rib ..... 2.
2. Posterior cingular list with less than six radial ribs ..... *Parahistioneis*, gen. nov.
2. Posterior cingular list with six or more radial ribs ..... *Ornithocercus* Stein (1883).

Ornithocercus Stein

Ornithocercus Stein, 1883, p. 25. Bütschli, 1885, p. 944, 1011. Schütt, 1896, p. 28. Delage & Hérouard, 1896, p. 386.
Parelion Schmidt, 1888, pl. 144, fig. 59–61.
Ornithocerus Schütt, 1893, fig. 83 (*lapsus pennae*).
Ornithoceras Gräf, 1909, p. 139 (*lapsus pennae*).

Diagnosis: — Body subcircular, subellipsoidal, subobovate, rounded subtriangular, or subtrapeziform in lateral outline, usually about as deep as long (length: depth, 0.76–1.24: 1), compressed bilaterally. Epitheca low, disk-like, its depth usually 0.37–0.67, seldom as little as 0.28 or as much as 0.88 the depth of body. Transverse furrow, as a rule, wide dorsally and wider dorsally than ventrally; dorsal width, 0.33–0.55 the depth of body; ventral width, 0.31–0.70 the dorsal width (exception *Ornithocercus splendidus*). Cingular lists large, anterior not stalked, posterior usually slightly narrower than anterior; width, 0.37–1.46 the depth of body; anterior with 4–24 radial ribs, inclined anteriorly at 25°–50°; posterior with 6–24 usually simple ribs, no cross-rib, inclined anteriorly at 30°–85°; besides ribs sometimes reticulation. Right sulcal list small, its ventral margin free (except in *O. formosus*). Left sulcal list large, extending at least to near antapex, sometimes to posterior cingular list; two- to five-lobed, rounded, or squarish; width at lobes 0.27–1.92 the depth of body; behind fission rib 4–15 strong radial ribs (except in *O. formosus*, that has only one) and often reticulation.

Type. — *Ornithocercus magnificus* Stein.

Organology: — The *body* (*theca*) in Ornithocercus is simple and more uniform in shape than in any of the other large genera of this tribe. Usually it is somewhat asymmetrical in lateral view, due largely to the shape of the transverse furrow and to the inclination of the longitudinal axis, but symmetrical or subsymmetrical specimens may be found in a few species, for instance, in *O. splendidus* (Figure 77: 4; 85: 3) and in *O. quadratus* (Figure 87: 1–4). In dorsoventral view it appears always to be symmetrical. Sometimes the longitudinal axis is perpendicu-

lar to the girdle (see the figures just mentioned), but usually it is slightly (1°–10°) deflected posterodorsally; the maximum deflection as yet recorded is about 20° (*O. heteroporus*).

When seen in lateral view, the body usually is about as deep as long, the typical ratio between the length and the depth being 0.90–1.10: 1. In exceptionally deep specimens (*cf. Ornithocercus splendidus*) this ratio may be 0.76: 1; and in the specimen with the most elongated body found in the material of the Expedition (belonging to *O. splendidus*) it was as high as 1.24: 1. As a rule, the body is deepest in or near the middle, and only in exceptional cases (some specimens of *O. splendidus*) the greatest depth is located at the girdle. In most species it is subcircular in lateral outline, but it may be subellipsoidal, subobovate, rounded subtriangular, or subtrapeziform (*O. heteroporus*, *O. splendidus*). In dorsoventral view the body usually is subellipsoidal, widest in the middle, 1.4–1.7 times longer than wide, well rounded posteriorly and narrowly rounded conical anteriorly (Plate 17, fig. 4, 6); but it may be broadly ellipsoidal, with broadly rounded apices, and about 1.14 times longer than wide (*O. heteroporus*, Plate 18, fig. 1), or again its outline may be obovate (*O. splendidus*, Figure 77: 7).

The *epitheca* forms an ellipsoidal, gently vaulted to flat disk, the dorsoventral diameter of which decidedly exceeds the transdiameter (Schütt, 1895, pl. 5, fig. 22). In lateral view it usually is somewhere between 0.37 and 0.67 as deep as the hypotheca, gently convex to flat, highest in or dorsally to the center (only seldom ventrally to the center), and inclined ventroposteriorly at 5°–15°. Sometimes (*Ornithocercus heteroporus*) its depth may be only 0.28, sometimes (*O. splendidus*) as much as 0.88 the greatest depth of the hypotheca; and it may be horizontal (*O. heteroporus* and *O. splendidus*).

Due to the small height of the epitheca, the *transverse furrow* is situated near the anterior end of the body. Its distal portion is not displaced posteriorly, in other words, it does not form a spiral about the body; and its postmargin is always straight or nearly so. In the relatively primitive species, *Ornithocercus splendidus*, it is of subuniform or nearly subuniform width throughout, and its width is 0.11–0.28 the greatest depth of the body. In the remaining species it is more or less strikingly wider dorsally than ventrally; the dorsal width is 0.33–0.55 the greatest depth of the body, and the ventral width is 0.31–0.70 the dorsal width. Usually it is gently or moderately concave dorsally, but it may be flat or even slightly convex. Ventrally it is, as a rule, gently convex to flat.

The *longitudinal furrow* is about half as long as the hypotheca or slightly more and at most but slightly impressed.

While in Phalacroma, Dinophysis, and most of the other genera of this tribe, the *lists of the furrow* are comparatively narrow and simple, they are characterized in Ornithocercus by their very large size and high structural differentiation. They arise from low and narrow basal ridges (Plate **17**), and in spite of their large size they are hyaline and very delicate.

Of the *cingular lists* the anterior usually is slightly wider than the posterior; and the posterior is, as a rule, somewhat more inclined anteriorly than the anterior. In most specimens the width of these lists is somewhere between 0.37 and 0.90 the greatest depth of the body, and the anterior inclination somewhere between 25° and 50° in the case of the anterior list and between 30° and 85° in the case of the posterior. *Ornithocercus splendidus,* which is unique in the excessive width of these lists (0.77–1.46 the greatest depth of the body), is also characterized by the fact that the two lists have about the same anterior inclination (30°–50°). The dorsal and ventral inclination are sometimes about equal; sometimes the ventral is slightly steeper. The anterior cingular list has on each valve between four and twenty-four, often between five and ten, complete, subequidistant radial ribs. These ribs may be simple or more or less anastomosing, and sometimes (Plate **16**, fig. 1) they have distally candelabra-like branches. In *O. formosus* (Plate **17**, fig. 4) the dorsal of these ribs is branched in the same manner as in many of the species of Histioneis. Besides these complete ribs, there is frequently a varying number of short, marginal radial ribs, which may be simple or anastomosing. The tips of the ribs may extend slightly beyond the margin of the list (Plate **17**, fig. 1). The posterior cingular list is on each valve furnished with between six and twenty-four, as a rule between eight and nineteen, complete, subequidistant radial ribs. These ribs usually are simple or one or a few of them are branched proximally. In exceptional cases (*Ornithocercus splendidus,* Plate **17**, fig. 3) they anastomose, or (Plate **17**, fig. 1, 5) the dorsal and ventral of them are connected by reticulation. In a few specimens (Plate **16**, fig. 3) this list has besides the complete ribs some short, marginal radial ribs. The anterior cingular list is always closed ventrally. On the other hand, we are not able to decide as to whether or not the posterior is always open ventrally.

The *sulcal lists* form a direct continuation of the posterior cingular list and run parallel to each other on either side of the longitudinal furrow. The entire right sulcal list and the portion of the left sulcal list which is behind the fission rib belong to the right valve; and the portion of the left sulcal list in front of the fission rib belongs to the left valve.

The *right sulcal list,* which always is strikingly smaller than the left, exhibits

fairly decided variations in size and shape. In most species its ventral margin is free, but in *Ornithocercus formosus* this margin appears to be attached to the left sulcal list, just as in Histioneis, so that these two lists thus form a canal open posteriorly and presumably also anteriorly (Plate **17**, fig. 5). In some species (*e.g.*, *Ornithocercus magnificus*) this list is very small, ending at or near the fission rib of the left sulcal list, and subtriangular or rounded triangular, decreasing gradually in width posteriorly. In other species (Figure 85: 5; Plate **16**, fig. 1; Plate **17**, fig. 1, 7) it is comparatively large and extends far beyond the fission rib of the left sulcal list (but never quite as far as to the midline of the body). In these species it either is of subuniform width throughout the greater portion of its length and gently (Plate **17**, fig. 1) or strongly (Plate **16**, fig. 1) convex posteriorly, or (Plate **17**, fig. 7) it decreases strikingly in width in its posterior half and has an irregularly sigmoid ventral margin. Its maximum width does not, as a rule, exceed the dorsal width of the transverse furrow. In some species this list appears to lack structural differentiation; in others it has one or more regular or irregular ribs (Plate **16**, fig. 4, 1), or it may be reticulated (Plate **17**, fig. 1, 5). Its size, shape, and structure are frequently quite variable within the species.

The *left sulcal list*, which is very large, has undergone in this genus more striking modifications than any other structure; and the species hitherto established are based largely on the differences in this list. As a rule, it is decidedly variable even within the species. In the most primitive members of this genus (*Ornithocercus heteroporus* and *O. splendidus*, Figure 75, 77) this list is two-lobed and ends at or near the antapex of the body; the lobes are subequal or nearly so, and narrowly rounded or subacute. In the remaining species this list extends to the dorsal side of the body and sometimes (Plate **16**, fig. 1; Plate **17**, fig. 7) it encircles the hypotheca, ending at the posterior cingular list. Among these species one, *O. formosus* (Plate **17**, fig. 5), is characterized by having this list strongly two-lobed, the lobes being narrowly rounded or subacute; the others have it three-lobed (*O. magnificus*, *O. thurni*, and *O. carolinae*, Figure 79, 81, 89), four- or even five-lobed (*O. steini*, Figure 83), rounded (*O. orbiculatus*, Plate **17**, fig. 7), or squarish (*O. quadratus*, Figure 86). When it is three-lobed, the lobes usually are narrowly rounded and either subequal, as in *O. magnificus* and *O. thurni*, or the middle (antapical) one of them is strikingly larger than the others, as in *O. carolinae*. The lobes either are well marked, as in Figure 81: 6 of *O. thurni*, or nearly indistinguishable, as in Figure 83: 10, 11, of *O. steini*. The width of this list, measured at the tips of the lobes, is usually somewhere between 0.50 and 1.92 the greatest depth of the body; in *O. carolinae* the width at the dorsal lobe may

amount to only 0.27 the greatest depth of the body. The fission rib, which is made up of two members, one belonging to the left, the other to the right valve, and which arises at or near the middle of the body, usually is straight or nearly so, and is subhorizontal or somewhat inclined posteriorly. As a rule, its inclination lies between 1° and 25°; its maximum inclination is about 55° (see *O. carolinae* and *O. formosus*, Plate **17**, fig. 1, 5). In exceptional cases (*O. quadratus* f. *intermedia*, Figure 87: 15–20) its posterior member is recurved posteriorly. In front of the fission rib this list usually has, besides the anterior main rib, *i.e.*, the rib at the junction of this list and the posterior cingular list, one or a few regular or irregular radial ribs and frequently a more or less developed reticulation (Plate **17**, fig. 1, 3, 5, 7, 9). Behind the fission rib it sometimes (*O. formosus*, Plate **17**, fig. 5) has only one strong radial rib, but usually (*e.g.*, *O. magnificus*, *O. thurni*, *O. steini*, Figure 79, 81, 83) there are from four to seven ribs of this kind; and in one species (*O. carolinae*, Plate **17**, fig. 1) the number of these ribs is 13–15. These ribs, which afford very important taxonomic characters, and which in the present paper have been named the *a*-, *b*-, *c*-, etc., ribs, the *a*-rib being the one situated most dorsally, either are simple and nearly straight (*e.g.*, in *O. quadratus* f. *schütti*, Figure 86: 7–14), or they are more or less branched and irregular (*e.g.*, in *O. quadratus* f. *assimilis*, Figure 87: 1–8). The tips of these ribs are in several species connected by a submarginal rib, which may be fairly heavy (*e.g.*, in *O. magnificus*, Figure 79) or very fine (*O. steini*, Figure 83), and which may be present or absent in the same species. Besides the radial and submarginal ribs a more or less developed reticulation frequently characterizes this portion of the list; reticulation is especially found in the tips of the lobes and dorsally to the dorsal radial rib (Plate **17**, fig. 1, of *O. carolinae*). The great variations observed by us in the structural differentiations of this list seem to be due largely to age, to irregularities in the regeneration of local injuries, and to processes of resorption and growth in adjustment to the requirements of flotation. Generally speaking, the older a specimen is, the more complicated is the structure of this list (see Schütt, 1900a).

Parasagittal lists have not been recorded in this genus.

The *flagellar pore* is a rounded or somewhat elongated opening of moderate size, located in the transverse furrow, in other words, on the right valve, at or just behind the posterior cingular list. Its largest diameter usually does not exceed half the ventral width of the transverse furrow. No counterparts have been found to the pores recorded in Phalacroma (Plate **3**, fig. 1, 2, of *Phalacroma pulchrum* and *P. giganteum*) on the ventral side of the left valve, near the sagittal suture,

and just in front of the anterior cingular list. It is, however, not impossible that such pores do exist in Ornithocercus.

The *longitudinal flagellum* has been figured only in *Ornithocercus magnificus* (by Schütt, 1895, pl. 5, fig. 21: 1). In this species it originates in the flagellar pore and has a length about 1.5 the greatest depth of the body. The *transverse flagellum* has not been observed as yet; presumably it is well developed, lies in the girdle, and encircles the body from the left around to the right.

The structure of the *thecal wall* is subject to but slight variations in this genus. In all the species the entire theca has a fairly great number of scattered pores. The most primitive species (*Ornithocercus heteroporus* and *O. splendidus*) may have no other structural differentiation, but in all the higher members the hypotheca is areolate. The areoles are rounded or angular, of moderate and often subuniform size, and each of them has a pore in the middle; sometimes (Plate **17**, fig. 5, 7) they are close-set, sometimes (Plate **17**, fig. 1) more or less spaced. In some species (*e.g.*, *O. magnificus*, Plate **16**, fig. 3) the (10–20) areoles that border the girdle posteriorly are larger than the others. Sometimes (Plate **16**, fig. 1) the areoles are developed only on the central portion of the hypotheca.

The *protoplasmic contents* have been figured in one species only, viz., in *Ornithocercus magnificus* (Schütt, 1895, pl. 5, fig. 21: 2). In this species the *nucleus* is large, ovoidal, is located posterodorsally, and has a moniliform chromatin reticulum. Two fairly large *pusules* open at the flagellar pore by a slender canal. *Chromatophores* are not present (Schütt, 1895, p. 64). *Metaplasmic inclusions* of various kinds, such as globules of fats and oils, have been found. See also Schütt (1895) and Bütschli (1885). *Phaeosomes*, ovoidal or spheroidal, small or of medium size, are often found in the girdle. Their color is green or yellowish green.

The *length of the body* ranges within the genus from about 27 μ (*Ornithocercus heteroporus*) to about 68 μ (*O. thurni*), according to our own measurements made on the material of the Expedition. Measurements made on previously published figures give a maximum length of more than 80 μ.

Reproduction: — Just as in Phalacroma and Dinophysis and in the other genera of this tribe, binary fission is the only known mode of reproduction in Ornithocercus. The details of this procedure are not known, but in all probability they are about the same as in Phalacroma (see the corresponding section of this genus, p. 51).

At least in some species (see, for instance, Plate **18**, fig. 4–6 of *Ornithocercus thurni*) the two schizonts remain attached to each other for some time by means

of an accessory ridge along the anterior or middle portions of the dorsal margin of the hypotheca. No data are available as to the length of this period of attachment, but presumably it is comparatively short. Since very few free specimens with traces of this ridge have been found, it appears plausible that this structure is resorbed shortly after the separation of the schizonts. Usually this ridge is fairly wide; its width may even be subequal to half the greatest depth of the body. Its shape is squarish, and its dorsal margin is deeply serrated in most specimens. It may be nearly without structural differentiation, but usually it is reticulated; sometimes (Plate **18**, fig. 2) the reticulation is fine, sometimes (Plate **18**, fig. 6) the meshes are large and regular in arrangement. While in *Dinophysis miles* as many as eight adhering specimens have been found (Weber-van Bosse, 1901, pl. 17, fig. 3), in Ornithocercus never more than two specimens have been recorded attached to each other. The adaptive significance of this phenomenon possibly is that it facilitates the remaining of the schizonts in the horizontal position during the period when their lists are relatively undeveloped. In the horizontal position these organisms offer the maximum surface of resistance.

As a rule, the schizonts are of about the same size, shape, and structure as their parent. Sometimes, however, there is a more or less pronounced difference in the size or in the shape as well as in the structure. This phenomenon, which is illustrated by Plate **18**, figure 2, 7–9, appears to be due to an increase in the rate of division beyond the rate of growth of the cytoplasm. Indeed, sometimes (Plate **18**, fig. 9) the fission takes place so rapidly that parts of the theca of the grandparent still remain unabsorbed. A striking feature of this mode of fission is that the ventral side of the body remains unchanged and that the reduction in size takes place largely dorsally, or dorsally and posteriorly (Plate **18**, fig. 9, 2). In some specimens the length as well as the depth of the body are reduced, the schizonts being more or less strikingly smaller but of about the same shape as the mother. In other cases only the depth is reduced, and the schizonts become more or less oblong. Plate **18**, figure 9, shows a specimen about as long as its grandparent but only about half as deep. In this manner specimens may originate which are so strikingly different from their ancestral type that a specific allocation is impossible or at least conjectural.

The significance and causes of the phenomenon described in the last paragraph are unknown. It is probably not an abnormality brought about by unfavorable factors in the surrounding medium, since most of the recorded specimens of this kind were found not in turbulent or relatively cold regions but in the South Equatorial Drift, *i. e.*, in the area characterized by hydrographic conditions more

stable and presumably more favorable to this genus than any of the remaining areas investigated by the Expedition. Hensen (1911, p. 152) probably refers to small specimens originated in this manner when he speaks of "Schwärmlinge . . . wie solches von Ornithocercus bekannt geworden ist." What happens to these small individuals? Do they succumb after they have reached a minimum size, or do they regain the size of their ancestors by the process of ecdysis or regulatory enlargement during growth? Or, again, do they form a stage preparatory to sexual reproductions? No data bearing on these interesting and important questions are available at the present writing.

Megacytic specimens have been found in some species, for instance, in *Ornithocercus magnificus s. str.*, but the intercalary zone appears never to attain any considerable width.

It may finally be mentioned in this connection that we are unable to furnish data on the mode of reproduction in the closely related genera Parahistioneis and Histioneis, and that no information on this point is published at present. However, in all probability these genera resemble Phalacroma in this respect.

Distribution: — Ornithocercus is marine, eupelagic, of circumequatorial distribution, and all its species are true warm-water forms, being restricted to tropical, subtropical, and warm-temperate seas. The genus is a characteristic element of the group of beautiful and luxuriant plankton organisms that has aroused the admiration and been the source of the enthusiastic descriptions of the life of tropical waters by many investigators. It is one of the groups of organisms causing the striking contrast between the plankton of the equatorial and the polar regions. In the Atlantic Ocean, Ornithocercus has been recorded between lat. 45° N. and lat. 42° S.; in the Pacific Ocean its northern limit appears to be at about lat. 35° N. Some species, as *O. splendidus*, seem to be restricted to tropical and subtropical seas; others, as *O. thurni*, are predominantly tropical and subtropical but occur also in small numbers in warm-temperate waters; still others, as *O. magnificus*, are almost as frequent in warm-temperate as in tropical and subtropical seas. The distribution of the genus as a whole appears to be fairly well established. The general distribution of several of the species, on the other hand, must be regarded as rather uncertain, due to the broad concept of species held by several investigators (see, for instance, *O. magnificus*, the section on synonymy, p. 534), to the great difficulties of specific determinations, and to the fact that but few of the distributional data are accompanied by figures or descriptions by means of which the determinations of species by planktonologists may be checked and compared.

Although Ornithocercus appears always to lack chromatophores (Schütt, 1895, p. 64), it is found more commonly in surface waters than any other genus of Dinophysoidae. Most of the records of this genus published at the present writing are from surface hauls. It should be emphasized, however, that our knowledge of its vertical distribution is still very fragmentary. The only records based on catches made with closing nets available as yet are those of the VALDIVIA Expedition (see *O. splendidus*, *O. magnificus*, and *O. quadratus*, the sections on distribution, p. 526, 536, 570).

Most of the species seem to be rare. Some of them, however, as *Ornithocercus magnificus*, *O. thurni*, and *O. quadratus*, when compared with species of other genera of this tribe, are relatively common, and a sudden appearance in great numbers of *O. magnificus* has been recorded (Schiller, 1914, p. 14).

Representatives of Ornithocercus were found at 100 (78.7%) out of the 127 stations of the Expedition from which dinoflagellates were recorded. These 100 stations are distributed over the whole area covered by the Expedition in the following manner (Plate 28): —

2 (50.0%) out of the 4 stations in the California Current
13 (100.0%) out of the 13 stations in the Mexican Current
17 (100.0%) out of the 17 stations in the Panamic Area
8 (29.6%) out of the 27 stations in the Peruvian Current
9 (90.0%) out of the 10 stations in the Easter Island Eddy
4 (100.0%) out of the 4 stations in the Galapagos Eddy
40 (89.0%) out of the 45 stations in the South Equatorial Drift
3 (100.0%) out of the 3 stations in the South Equatorial Current
2 (100.0%) out of the 2 stations in the Equatorial Counter Current
2 (100.0%) out of the 2 stations in the North Equatorial Current

The numbers of these 100 stations are as follows:—4580, 4583 (California Current); 4587, 4588, 4590, 4592, 4594, 4596, 4598, 4600, 4604, 4605, 4607, 4545, 4546 (Mexican Current); 4609, 4611, 4613, 4615, 4617, 4619, 4623, 4624, 4627, 4631, 4634, 4635, 4637, 4638, 4639, 4640, 4644 (Panamic Area); 4646, 4647, 4648, 4650, 4659, 4664, 4671, 4676 (Peruvian Current); 4689, 4691, 4692, 4695, 4696, 4697, 4698, 4699, 4700 (Easter Island Eddy); 4713, 4714, 4715, 4716 (Galapagos Eddy); 4679, 4680, 4681, 4682, 4683, 4684, 4685, 4686, 4687, 4701, 4702, 4704, 4705, 4707, 4709, 4711, 4712, 4717, 4718, 4719, 4720, 4721, 4722, 4723, 4724, 4725, 4727, 4728, 4729, 4730, 4731, 4732, 4733, 4734, 4735, 4736, 4737, 4739, 4740, 4741(South Equatorial Drift); 4742, 4743, 4540 (South Equatorial Current); 4541, 4542 (Equatorial Counter Current); 4543, 4544 (North Equatorial Current).

At fifty-one out of these 100 stations Ornithocercus was taken in vertical hauls and at fifty-seven in surface hauls. Most of the vertical hauls are from

300–0 fathoms, some are from 800, 150, 100–0 fathoms. Vertical hauls were made at only sixty-eight out of the 127 stations. The genus was thus found at 75.0% of the stations at which vertical hauls were made.

Disregarding the stations at which surface catches only were made, the record stations are distributed over the area covered by the Expedition in the following manner: —

2 (50.0%) out of the 4 stations in the California Current
5 (100.0%) out of the 5 stations in the Mexican Current
6 (100.0%) out of the 6 stations in the Panamic Area
7 (31.8%) out of the 22 stations in the Peruvian Current
5 (100.0%) out of the 5 stations in the Easter Island Eddy
2 (100.0%) out of the 2 stations in the Galapagos Eddy
23 (100.0%) out of the 23 stations in the South Equatorial Drift
1 (100.0%) out of the 1 station in the South Equatorial Current

There were no vertical hauls made in the Equatorial Counter Current or in the North Equatorial Current.

The numbers of these fifty-one vertical stations are as follows: — 4580, 4583 (California Current); 4587, 4590, 4594, 4598, 4605 (Mexican Current); 4609, 4613, 4617, 4634, 4637, 4638 (Panamic Area); 4646, 4647, 4648, 4650, 4659, 4671, 4676 (Peruvian Current); 4689, 4691, 4695, 4697, 4699 (Easter Island Eddy); 4713, 4715 (Galapagos Eddy); 4679, 4681, 4683, 4685, 4687, 4701, 4705, 4707, 4709, 4711, 4717, 4719, 4721, 4722, 4724, 4728, 4730, 4732, 4734, 4736, 4737, 4739, 4740 (South Equatorial Drift); 4742 (South Equatorial Current).

Surface catches and stomachs of Salpa taken in surface waters (eighty-one surface catches and twenty-four samples of Salpa stomachs) were examined from eighty-two stations. As previously mentioned, the genus was taken at fifty-seven, *i. e.*, at 69.5% of all the surface stations. Taking into consideration the surface stations only, these fifty-seven record stations are distributed in the following manner: —

1 (25.0%) out of the 4 stations in the California Current
9 (100.0%) out of the 9 stations in the Mexican Current
13 (100.0%) out of the 13 stations in the Panamic Area
3 (15.0%) out of the 20 stations in the Peruvian Current
4 (80.0%) out of the 5 stations in the Easter Island Eddy
2 (100.0%) out of the 2 stations in the Galapagos Eddy
19 (82.6%) out of the 23 stations in the South Equatorial Drift
2 (100.0%) out of the 2 stations in the South Equatorial Current
2 (100.0%) out of the 2 stations in the Equatorial Counter Current
2 (100.0%) out of the 2 stations in the North Equatorial Current

The numbers of these fifty-seven surface stations are as follows: — 4583 (California Current); 4588, 4590, 4592, 4596, 4600, 4604, 4607, 4545, 4546 (Mexi-

can Current); 4611, 4615, 4617, 4619, 4623, 4624, 4627, 4631, 4635, 4638, 4639, 4640, 4644 (Panamic Area); 4646, 4648, 4664 (Peruvian Current); 4692, 4696, 4698, 4700 (Easter Island Eddy); 4714, 4716 (Galapagos Eddy); 4680, 4682, 4684, 4686, 4702, 4704, 4709, 4712, 4718, 4720, 4723, 4725, 4727, 4729, 4731, 4733, 4735, 4740, 4741 (South Equatorial Drift); 4743, 4540 (South Equatorial Current); 4541, 4542 (Equatorial Counter Current); 4543, 4544 (North Equatorial Current).

Thus if we use either the records from vertical hauls or the records from surface hauls as indicators of the distribution of Ornithocercus, our data show that this genus is about evenly distributed throughout the area examined by the Expedition except in the California Current and in the Peruvian Current, for the genus is relatively rare in waters entering the tropics from temperate regions. The genus occurred at all the vertical as well as at all the surface stations in the Mexican Current, Panamic Area, Galapagos Eddy, South Equatorial Current, Equatorial Counter Current, and North Equatorial Current. In the Easter Island Eddy and in the South Equatorial Drift it occurred at all the vertical stations and at 80.0% and 82.6%, respectively, of the surface stations. In the California Current it was absent from the northern stations; and in the Peruvian Current it occurred at only 31.8% of the vertical stations and at 15.0% of the surface stations. The scarcity of the genus in the Peruvian Current is also evident if the number of species found at each record station is considered. At not less than three out of the eight record stations, only one species was found, while in other regions, as a rule, several species were found at each station (Plate 28).

The rare occurrence of Ornithocercus in the Peruvian Current is probably due to the fact that this current is relatively cool while the species of this genus are distinctly warm-water forms. The cause of its absence from the northern stations in the California Current is probably that this current comes from the north and has not been warm for a sufficient length of time until it reaches the middle of Lower California. Our temperature records for the stations of this current, viz., Stations 4571, 4574, 4576, 4580, and 4583, the last located near Point Lucas, the southernmost point of Lower California, are as follows: — 71°, 69°, 69°, 76°, and 83°. It should be observed, however, that the genus occurs, although rarely, as far to the north as at San Diego, California, where it has been taken repeatedly by the senior author in the autumn when other tropical elements appear in the plankton.

According to their distribution within the area investigated by the Expedition, the species of this genus can be divided into two groups, viz., those relatively frequent in the Mexican Current and the Panamic Area, and those absent from

or very rarely occurring in these regions. *Ornithocercus magnificus* (Figure 80), *O. thurni* (Figure 82), *O. steini* (Figure 84), and *O. quadratus* (Figure 88) belong to the first of these two groups; while *O. heteroporus* (Figure 76), *O. splendidus* (Figure 78), and *O. carolinae* (Figure 90) belong to the second. The reasons why the last three species avoid the Mexican Current and the Panamic Area are obscure. It cannot be due to too low temperature, since this is about the same as in the South Equatorial Drift where these species are relatively frequent. It may be that the unusually turbulent current conditions in these regions are responsible for this phenomenon.

There are 236 records of species of Ornithocercus from vertical catches. Out of these 236 records, one (0.4%; Station 4613) showed a frequency of 16%; one (0.4%; Station 4598) showed 15%; one (0.4%; Station 4613) showed 12%; one (0.4%; Station 4721) showed 11%; three (1.3%; Stations 4713, 4740, 4742) showed 10%; two (0.8%; Stations 4695, 4699) showed 9%; four (1.7%; Stations 4605, 4609, 4617, 4728) showed 8%; six (2.5%; Stations 4634, 4638 [2 records], 4715, 4721, 4722) showed 7%; three (1.3%; Stations 4637, 4638, 4689) showed 6%; five (2.1%; Stations 4613, 4617, 4691, 4724, 4736) showed 5%; twelve (5.1%; Stations 4590 [2 records], 4598, 4605, 4609, 4638, 4683, 4697, 4722, 4724, 4730, 4740) showed 4%; ten (4.2%; Stations 4598, 4634 [2 records], 4637, 4681 [2 records], 4732, 4734, 4737, 4739) showed 3%; thirty (12.7%; Stations 4580, 4583, 4587, 4605, 4617, 4634, 4646, 4650, 4681, 4687, 4689 [2 records], 4691, 4695, 4697, 4701 [2 records], 4709, 4715, 4717, 4719, 4728, 4730, 4734, 4737 [2 records], 4739, 4740 [2 records], 4742) showed 2%; forty-four (18.6%; Stations 4583, 4594, 4617, 4637, 4647, 4648, 4679, 4683, 4685 [2 records], 4687, 4689, 4691, 4695 [2 records], 4697, 4699 [2 records], 4701 [2 records], 4705 [2 records], 4707, 4711, 4715, 4717, 4722, 4724, 4728 [2 records], 4732 [4 records], 4734, 4736 [3 records], 4737 [3 records], 4739 [2 records], 4742) showed 1%; 113 (47.8%) showed a frequency of less than 1%.

There are 156 records of species of this genus from surface catches. Out of these 156 records, one (0.6%; Station 4619) showed a frequency of 37%; one (0.6%; Station 4546) showed 21%; one (0.6%; Station 4607) showed 15%; one (0.6%; Station 4607) showed 14%; two (1.3%; Stations 4604, 4543) showed 13%; three (1.9%; Stations 4607, 4615, 4545) showed 10%; two (1.3%; Stations 4635, 4696) showed 9%; one (0.6%; Station 4543) showed 8%; two (1.3%; Stations 4590, 4604) showed 7%; four (2.6%; Stations 4600, 4604, 4619, 4546) showed 6%; six (3.8%; Stations 4596, 4600, 4617, 4692, 4696, 4545) showed 5%; eight (5.1%; Stations 4607, 4615, 4619, 4635, 4638, 4714, 4720, 4741) showed 4%; eight (5.1%;

Stations 4588, 4600, 4615, 4640, 4733, 4542, 4545, 4546) showed 3%; 26 (16.7%; Stations 4592 [2 records], 4596, 4600, 4615, 4617, 4619, 4624, 4627, 4631 [2 records], 4638 [2 records], 4639, 4648, 4682, 4692, 4712, 4714, 4716, 4720, 4731, 4733, 4741, 4540, 4543) showed 2%; 29 (18.6%; Stations 4590 [2 records], 4596, 4604, 4617, 4638, 4639, 4640 [3 records], 4644, 4702, 4712, 4716 [2 records], 4720, 4725, 4729, 4731 [2 records], 4733 [3 records], 4735, 4541 [3 records], 4542 [2 records]) showed 1%; 61 (39.1%) showed less than 1% or did not have the frequency established.

As will be seen from a comparison between the last two paragraphs and the corresponding paragraphs in the sections on the distribution of the other genera of Dinophysoidae, the average frequency of the individual species of Ornithocercus is higher than in any other genus of this family. Furthermore, the relative number of surface records is decidedly higher than in other genera, as will be seen from the following values:

Triposolenia	vertical records,	156	surface records,	0	ratio,	∞ : 1
Histioneis	"	"	94	"	"	17	"	5.5 : 1
Amphisolenia	"	"	210	"	"	42	"	5.0 : 1
Phalacroma	"	"	309	"	"	74	"	4.2 : 1
Dinophysis	"	"	170	"	"	44	"	3.9 : 1
Ornithocercus	"	"	236	"	"	156	"	1.5 : 1

The genus Parahistioneis is not considered in this connection since most of its surface records refer to specimens found in Salpa stomachs.

Coincident occurrence of different species of Ornithocercus in catches from 300 (800, 150, 100)–0 fathoms is recorded at the following of the fifty-one stations mentioned above:—eight species occurred coincidently at four stations (7.8%; Stations 4701, 4722, 4724, 4737); seven species at four stations (7.8%; Stations 4730, 4732, 4734, 4742); six species at eight stations (15.7%; Stations 4590, 4691, 4699, 4705, 4721, 4728, 4739, 4740); five species at nine stations (17.7%; Stations 4583, 4587, 4613, 4681, 4695, 4697, 4709, 4717, 4736); four species at fourteen stations (27.4%; Stations 4598, 4605, 4609, 4617, 4634, 4637, 4638, 4646, 4647, 4683, 4685, 4689, 4713, 4719); three species at seven stations (13.7%; Stations 4594, 4650, 4671, 4679, 4687, 4707, 4715); two species at one station (2.0%; Station 4711).

Coincident occurrence of different species of this genus in surface hauls is recorded at the following of the fifty-seven surface stations mentioned above: five species occurred coincidently at three stations (5.3%; Stations 4617, 4733, 4743); four species at fourteen stations (24.6%; Stations 4588, 4592, 4600, 4604, 4607,

4615, 4619, 4638, 4640, 4731, 4741, 4540, 4541, 4542); three species at sixteen stations (28.1%; Stations 4583, 4590, 4596, 4631, 4635, 4639, 4644, 4692, 4712, 4716, 4720, 4727, 4729, 4543, 4545, 4546); two species at thirteen stations (22.8%; Stations 4611, 4623, 4646, 4682, 4686, 4696, 4700, 4702, 4714, 4718, 4723, 4725, 4735).

Of the nine species of this genus found in the material of the Expedition not less than eight were recorded from surface hauls. The number of surface records of each of these eight species is as follows:—*Ornithocercus magnificus*, 42 records, *i.e.*, at 55.3% of all the record stations of this species; *O. steini*, 37 records (54.4%); *O. thurni*, 36 records (48.6%); *O. quadratus*, 33 records (43.4%); *O. splendidus*, 4 records (11.5%); *O. heteroporus*, 2 records (13.5%); *O. carolinae*, 1 record (4.2%); *O. orbiculatus*, 1 record (100.0%); *O. formosus*, no record (0.0%). A fact worth emphasizing in this connection is that *O. splendidus* is comparatively rare in surface waters in spite of the fact that it appears to be more highly adapted to flotation than any other species of this genus.

The distribution of Ornithocercus within the area investigated by the Expedition is such that we may expect to find that this genus is rather evenly distributed in all tropical and subtropical seas.

Historical Discussion and Systematics

Ornithocercus was established by Stein (1883, p. 25), who did not give any diagnosis but limited himself to a few remarks on the general organization and the systematic position of this genus and to the presentation of figures of five specimens, all, according to him, members of a single species, *O. magnificus*. Diagnoses of this genus were published later by Bütschli (1885, p. 1011), Delage and Hérouard (1896, p. 386), and Schütt (1896, p. 28). All these diagnoses are fairly satisfactory; the one by Schütt (1896) is by far the most nearly complete and displays the best evaluation of the systematic importance of the individual characteristics. No extensive description and discussion of the morphology of this genus have been published at the present writing, and the amount of original observations presented is relatively small. The last fact is due to the limitation of most of the species to tropical and subtropical seas and to the complete absence of this genus from the northern European waters, which are the only areas that have been submitted as yet to intensive investigations.

Besides *magnificus* the following specific names of Ornithocercus are to be found in the literature:—*O. splendidus* Schütt (1893); *O. splendens* Schütt (1896); *O. quadratus* and *O. steini* Schütt (1900a); *O. carolinae*, *O. heteroporus*, and *O.*

serratus Kofoid (1907a); *O. formosus* and *O. orbiculatus* Kofoid and Michener (1911); *O. compactus*, *O. horridus*, and *O. papillosus* Hensen (1911); *O. assimilis* and *O. minor* Jörgensen (1923). Representatives of this genus were figured also by Pouchet (1883) under the name of *Dinophysis galea* and by Schmidt (1888) as *Parelion thurnii* (Schmidt considered his species a diatom). In the present paper the following new names have been established: *Ornithocercus quadratus* f. *schütti*, *O. quadratus* f. *simplex*, and *O. quadratus* f. *intermedia*.

Of the species mentioned in the last paragraph, *Ornithocercus compactus*, *O. horridus*, and *O. papillosus* were introduced by Hensen (1911) as *nomina nuda*, and there is no information published as yet as to their organization. *O. splendens* Schütt (1896) is a *lapsus pennae* for *O. splendidus*. *O. minor*, a name used by Jörgensen (1923) in his manuscript, is a synonym of *O. magnificus s. str.* The specimens represented by Pouchet (1883, fig. G: 1, 4) as *Dinophysis galea* cannot be assigned with certainty to species, due to the sketchy nature of the figures.

Ornithocercus magnificus Stein (1883) is not a homogeneous systematic unit. Schütt (1900a), who was the first to point out this fact, applied the name *magnificus* to the specimen represented by Stein's (1883) Plate 23, figure 1, and made the specimen represented by Stein's (1883) Plate 23, figure 3, the type of a new species, which he called *O. steini*. However, since specimens of the last species had been figured previously as *Parelion thurnii* by Schmidt (1888) in a manner leaving no doubt as to their specific allocation, *steini* must be replaced by *thurni* as the name of this species. The specific name *steini* thus should have been discarded as a synonym, had it not been for the fact that out of the three specimens figured by Schütt (1900a) as *Ornithocercus steini*, only one, his figure 7, is referable to this species as conceived in the present paper. The two other specimens, his figures 5 and 6, are, according to our opinion, fairly young and undifferentiated members of a species later described and figured by Kofoid (1907a) as *O. serratus*. Under these circumstances the name *O. steini s. str.* has to be maintained for these two specimens of Schütt (1900a), and *O. serratus* Kofoid must be discarded as a synonym. *O. orbiculatus* Kofoid and Michener (1911) may be based on an abnormal specimen of *O. steini s. str.* and thus its specific status must be regarded as uncertain. *O. assimilis* Jörgensen (1923) has in the present paper been referred to *O. quadratus* under the designation *O. quadratus* f. *assimilis*. However, it should be emphasized that there are fairly strong reasons suggesting the specific independence not only of this *forma* but also of the remaining four *formae* included by us in this species, viz., f. *quadrata*, f. *schütti*, f. *simplex*, and f. *intermedia*. With regard to the specific differentiation between *Ornithocercus carolinae* and

Histioneis [*Parahistioneis*] *francescae*, see the first of these two species, the section on comparisons (p. 575). Some of the specimens of *Ornithocercus carolinae* are transitional to *Histioneis francescae*. Jörgensen (1923, p. 38), who accepted *Ornithocercus carolinae* as a valid species, even suggested that these two forms "may perhaps be identical." We consider it necessary to treat them tentatively as specifically distinct.

Thus out of the species of Ornithocercus established as yet, only eight have been regarded in the present paper as valid, viz., *O. carolinae* Kofoid (1907a), *O. formosus* Kofoid and Michener (1911), *O. heteroporus* Kofoid (1907a), *O. magnificus* Stein (1883) *s. str.*, *O. quadratus* Schütt (1900a), *O. splendidus* Schütt (1893), *O. steini* Schütt (1900a) *s. str.*, and *O. thurni* (Schmidt, 1888); and of *O. quadratus* there are five *formae*, which *may* be specifically independent.

All the descriptions of species published up to the present writing are very incomplete and include no or but few data of variation. The descriptions published by Kofoid (1907a) and Kofoid and Michener (1911) are preliminary and based on the same material as those of the present paper. The extraordinary variability, partly due to regulatory processes, and the uncertainty of specific delimitations have rendered the taxonomy of this genus very difficult, and the synonymies of some of the common species, viz., *Ornithocercus magnificus s. str.* and *O. thurni* are tangled almost beyond the possibility of unravelling.

No subdivision of this genus has been attempted as yet, with the exception of the establishment by Murray and Whitting (1899, p. 332) of the subgenus Paraschüttia, which was based on a single species, *Ornithocercus splendidus*.

A few contributions to the morphology of this genus were made by Bütschli (1885, p. 944) and Schütt (1895, p. 19, 23, 54, 64, 112, 114, 116, 130, 131, 136, 138). Schütt (1899, 1900a) submitted the growth and differentiation of the thecal wall and of the lists to a quite detailed analysis. A few remarks as to the adaptiveness of the lists in flotation were made by Carisso (1911), Gran (1912a, 1912b), Schütt (1893), and Steuer (1910, 1911). Some suggestions as to the functions of the furrows and lists were made by Francé (1923). Hensen (1911, p. 152) mentions the formation in this genus of small specimens, "Schwärmlinge," the results of rapid binary fission.

Contributions to our knowledge of the distribution of Ornithocercus are to be found in the following papers, not specifying those previously mentioned in this section:— Cleve (1897a, 1900b, 1901a, 1901c, 1902b, 1903b), Cleve, Ekman, and Pettersson (1901), Daday (1888), Entz (1902b, 1905), Faria and Cunha (1917), Forti (1922), Gräf (1909), Hensen (1895), Issel (1921), Jörgensen (1911),

Karsten (1906, 1907), Kofoid (1911), Lemmermann (1899a, 1901a, 1904, 1905), Lindemann (1924, 1925), Lohmann (1902, 1908, 1920), Mangin (1906), Murray and Whitting (1899), Okamura (1907, 1912), Ostenfeld (1898a, 1915), Ostenfeld and Schmidt (1901), Pavillard (1905, 1916), Schiller (1912, 1912a, 1914), Schmidt (1901), Schröder (1900a, 1906a, 1906b, 1909, 1911), Stüwe (1909), Whitelegge (1891), and Zacharias (1906). Of these investigators only Murray and Whitting (1899), Okamura (1907), and Schröder (1900a) give original figures by means of which the correctness of the determinations may be checked. Forti (1922) gives reproductions of previously published figures of the species recorded. Many, perhaps even most, of the data on the distribution of this genus should be accepted tentatively on account of the great difficulties implied in the determination of the species and to the broad concept of species held by several of the investigators.

References to Ornithocercus or minor contributions to our knowledge of this genus are found also in Balbiani (1884c), Bergh (1884), Calkins (1902), Chun (1886, 1903), Doflein (1909, 1911, 1916), Effenberger (1911), Entz (1902a), Fricke (1902), Gadeceau (1909), Goldschmidt (1909), Hensen (1891), Hjort (1911), Klebs (1912), Meunier (1910), Nathansohn (1910b), Oltmanns (1922), Schütt (1900b), Stiasny (1913), Théel (1909), Wallengren and Hennig (1911), Walther (1893), Willey and Hickson (1909), and Zacharias (1906a, 1907, 1911).

Accepting the decision of Murray and Whitting (1899), the following investigators use Histioneis instead of Ornithocercus as the generic name of the species of this genus:—Cleve (1900b, 1901a, 1901c, 1902b, 1903b), Cleve, Ekman, and Pettersson (1901), Entz (1902b, 1905), Forti (1922), Gadeceau (1909), Issel (1921), Lemmermann (1899a, 1901a, 1904, 1905a), Pavillard (1905, 1916), and Schröder (1900a, 1906a). With regard to this usage, see our treatment of the family Ornithocercidae, the section on the subdivisions (p. 494).

The following misspellings of the name Ornithocercus have been found by us: Ornithocerus Schütt (1893, fig. 83), Fricke (1902, p. 55), Théel (1909); Ornithoceras Gräf (1909, p. 139).

Adaptive and Systematic Value of the Characters. Principles used in the Description of the Species

Among all the genera of Dinophysoidae, Ornithocercus is the one that occurs most frequently in the surface waters of the tropical and subtropical seas. Since these waters are characterized by a lower buoyancy than the deeper strata in the same regions and the waters nearer to the poles, it appears reasonable to expect

this genus to be more highly differentiated for flotation than any other genus of this tribe. This expectation, however, is hardly borne out by a comparative morphological study. Ornithocercus undoubtedly is well adapted to flotation, but at the same time it has remained relatively primitive in many respects. The most striking examples of adaptations to flotation are not found within this genus but in the closely related genus Histioneis, in which the evolutionary processes have been carried to the extreme, resulting in a multitude of bizarre species, in most respects profoundly different from what might be called the basic type of this family. In regard to the shape of the theca, comparisons should also be made with the extreme genera Triposolenia and Amphisolenia.

Perhaps the most outstanding feature in the evolution of Ornithocercus is the fact that the theca has remained largely undifferentiated. Indeed, in none of the other large genera of this tribe has the theca been subject to so little change. It is, generally speaking, still subcircular in lateral outline, somewhat compressed bilaterally, and relatively large when compared with the whole organism. In other words, while in some of the other genera, *e.g.*, Triposolenia and Amphisolenia, the shape of the theca has been modified in response to the needs of flotation, Ornithocercus has remained nearly unchanged in this respect. Furthermore, while the members of Phalacroma and Dinophysis and of the other more or less primitive genera are fairly active swimmers, the organization of Ornithocercus indicates that the species of this genus are relatively slow. How, then, do these species keep themselves within their optimum habitat?

We suggest the following answer to this question. (*1*) The specific gravity is comparatively low, approaching that of the surrounding medium. This has been brought about in a twofold manner: first, the protoplasm contains fairly large pusules and inclusions of low specific gravity, such as fats and oils (Schütt, 1895, pl. 5, fig. 21:2); second, the transverse furrow and the thin cingular lists have been strikingly widened and include a large space filled principally with water. Thus the volume of the organism has been increased decidedly without a corresponding increase in the absolute weight. (*2*) In all the species the cingular lists are very large and undoubtedly act as parachutes, when the organism is in an upright position. In *Ornithocercus splendidus* these lists appear to be the principal means of flotation; they have an excessive development and a very wide spread (Figure 77:7). (*3*) The left sulcal list, which is very large and in most species extends nearly around the entire hypotheca, has at least two main functions: first, it increases very greatly the surface of resistance whenever the organism is turned upon one of its lateral faces, and the asymmetry and the lobes of this list

probably cause the organism in this position to descend in a spiral or zigzag line; second, it acts as a keel and a rudder, thus stabilizing the progressive movement. (*4*) The body is fairly small. In the largest specimens of this genus found in the material of the Expedition it was only 67.6 μ long, while of Phalacroma specimens were found by us measuring nearly 150 μ in length (*P. giganteum*). (*5*) In most species the surface friction is increased by structural differentiations in the theca and by the ribs and reticulation of the lists.

These five points are arranged according to their probable relative importance, the first being the most important. The investigators who previously have touched upon the phenomena of adaptation to flotation in Ornithocercus (see the historical discussion of this genus, p. 509) have mentioned only the second of these points.

The small size of the right sulcal list and the oblique position of the left sulcal list (the anterior portion of this list belongs to the left valve, the posterior portion to the right) should be correlated with the spiral mode of swimming. Francé (1923, p. 31), who interprets these organisms as miniature turbines, emphasizes the fact that the transverse furrow is narrower ventrally than dorsally and that the longitudinal furrow is narrowest posteriorly. "By this the instreaming water is retarded slightly in its course, producing a back-pressure, an economical overpressure which can be observed in the accelerated motion of the cell."

It may also be mentioned in this connection that besides decreasing the specific gravity of the organism, the large chamber enclosed by the girdle also functions as a container for the phaeosomes. However, this appears to be a secondary function, since most specimens have very few (or no) phaeosomes, occupying only a small portion of the enclosed space.

All the external characters have been utilized in our descriptions and separations of the species of this genus. However, since the size of the body varies greatly within the species, due to the mode of fission illustrated by Plate 18, figure 2, 7–9, and since most of these species agree fairly closely in the shape and structure of the body and in the size and shape of the cingular list, the most important distinguishing characteristics have been taken from the left sulcal list. Indeed, most of the species, *e.g.*, *Ornithocercus magnificus*, *O. thurni*, *O. steini*, *O. orbiculatus*, *O. quadratus*, and *O. formosus*, are based almost exclusively on differences in the size, shape, and structure of this list.

Unfortunately, the characters that are most profoundly modified within the genus as a whole also are subject to the most extreme fluctuations. These fluctuations, which are due to regulatory processes following binary fission, to adjust-

ments to flotation, and to irregularities in the regeneration following local injuries, render the establishment and characterization of the species exceedingly difficult. For instance, in the case of *O. quadratus* (Figure 86, 87) we have had to establish five *formae*, but these may possibly represent five different species. Furthermore, we found some specimens in the material of the Expedition that were too aberrant for certainty of specific assignment (Figure 92).

The following principles have been used by us in describing the species of this genus: — (*1*) When not otherwise stated, all characteristics refer to specimens in lateral view. (*2*) The terminology and the methods of measurement are largely the same as in Phalacroma and Dinophysis; see Figure 29. The angles are measured as in Figure 94 of Histioneis. It should be mentioned that the length of the fission rib and of the dorsal main rib (the *a*-rib) of the left sulcal list is measured from the base of the rib to the margin of the list; while the lengths of the remaining main ribs of this list behind the fission rib (the *b*-, *c*-, *d*-, and *e*-ribs) are measured from the bases of the ribs to the submarginal rib. (*3*) The terms length and depth of body refer to theca exclusive of lists. (*4*) The number of ribs in the cingular lists given in the diagnoses is the number on each valve.

Subdivisions. Relationships among the Species

No attempt at subdividing Ornithocercus has been carried out hitherto, with the exception of the establishment by Murray and Whitting (1899, p. 332) of the subgenus Paraschüttia, which was based on a single species, *Ornithocercus splendidus*. According to our opinion, this genus may be divided into three groups as follows.

1. Splendidus group: — *O. heteroporus* and *O. splendidus* (Figure 75, 77).

2. Magnificus group: — *O. magnificus s. str., O. thurni, O. steini s. str., O. orbiculatus, O. quadratus,* and *O. carolinae* (Figure 79, 81, 83; Plate 17, fig. 7; Figure 86, 87, 89).

3. Formosus group: — *O. formosus* (Figure 91).

1. Splendidus group (syn. Paraschüttia). Epitheca subhorizontal. Theca porulate and but seldom areolate. Width of transverse furrow and inclination of cingular lists variable. Left sulcal list two-lobed and ends at or near antapex of body. Ventral margin of right sulcal list free.

Of the two species of this group, *Ornithocercus heteroporus* is the more primitive in the size of the body and in the size and structure of the cingular lists. On the other hand, it is slightly more advanced in the width of the transverse furrow

and in the inclination of the lists. This species may be considered, on the whole, as the most primitive member of this genus.

2. Magnificus group. Transverse furrow decidedly wider dorsally than ventrally, and epitheca thus somewhat inclined ventroposteriorly. Theca areolate as well as porulate. Posterior cingular list somewhat more inclined anteriorly than the anterior. Left sulcal list three- to five-lobed, squarish, seldom two-lobed, and ends on dorsal side of body. Ventral margin of right sulcal list free.

Within this group, which comprises the typical members of this genus, *Ornithocercus carolinae* occupies structurally a somewhat isolated position, being characterized especially by the very large antapical lobe and the numerous radial ribs of the left sulcal list. The remaining species of this group are fairly closely related and have reached about the same evolutionary level. We are unable to decide which of them, all characters considered, is structurally closest to the ancestral type. *O. orbiculatus* may be found to be an aberrant specimen of *O. steini s. str.*

3. Formosus group. Transverse furrow decidedly wider dorsally than ventrally; epitheca somewhat inclined ventroposteriorly. Theca areolate and porulate. Posterior cingular list inclined anteriorly somewhat more than the anterior. Left sulcal list two-lobed and ends on dorsal side of body. Ventral margin of right sulcal list attached to left sulcal list.

Of these three groups the Splendidus group appears to be the most primitive. The obovate shape of the body in lateral as well as in dorsoventral view characteristic of most specimens of *Ornithocercus splendidus,* the subuniform width of the transverse furrow and the subequal inclination of the two cingular lists also found in this species, the subhorizontal position of the epitheca, and the ending of the left sulcal list at or near the antapex of the body are relatively primitive features suggestive of this assumption. On the other hand, it must be remembered that *O. splendidus* is more advanced than the other species of this genus in the excessive width of the cingular lists.

The Formosus group is somewhat isolated and occupies structurally in some respects a position intermediate between Ornithocercus and Histioneis (see *Ornithocercus formosus,* the section on comparisons, p. 579).

Key to the Species of Ornithocercus

1. Left sulcal list biangular . . . . . 2.
1. Left sulcal list not biangular . . . . . 5.
2. Left sulcal list ends at or near antapex . . . . . 3.
2. Left sulcal list ends on dorsal side of body . . . . . 4.
3. Length of body 34 μ or less; anterior cingular list 0.48–0.68 the depth of body . . . *O. heteroporus* Kofoid.
3. Length of body more than 34 μ; anterior cingular list 0.77–1.46 the depth of body. *O. splendidus* Schütt.

4. With only one strong rib in left sulcal list behind fission rib.....*O. formosus* Kofoid and Michener.
4. With more than one strong rib in left sulcal list behind fission rib.....*O. quadratus* Schütt.
5. Left sulcal list with three lobes; *a*-rib ends in dorsal lobe.....6.
5. Left sulcal list not with three lobes; *a*-rib does not end in dorsal lobe.....8.
6. Left sulcal list with more than eight radial ribs behind fission rib; its antapical lobe decidedly larger than the two other lobes.....*O. carolinae* Kofoid.
6. Left sulcal list with less than eight radial ribs behind fission rib; its three lobes subequal or nearly so.7.
7. *c*- and *e*-ribs of left sulcal list end at vertices of antapical and posteroventral lobes..*O. thurni* (Schmidt).
7. *c*- and *e*-ribs of left sulcal list do not end at vertices of antapical and posteroventral lobes.
O. magnificus Stein *s. str.*
8. Left sulcal list with four or more usually distinct lobes behind fission rib; ribs usually regular.
O. steini Schütt *s. str.*
8. Left sulcal list with rounded margin behind fission rib; its ribs irregular and partly incomplete.
O. orbiculatus Kofoid and Michener.

1. Splendidus Group. Both the species belonging to this group, viz., *Ornithocercus heteroporus* and *O. splendidus*, were found in the material of the Expedition.

Ornithocercus heteroporus Kofoid

Plate 18, fig. 1, 3. Figure 75, 76

Ornithocercus heteroporus Kofoid, 1907a, p. 206, pl. 12, fig. 70. Jörgensen, 1923, p. 37, 38, fig. 54.

Diagnosis: — Lateral outline obliquely subellipsoidal or subcircular. Cingular lists: anterior 0.48–0.68, posterior 0.37–0.60 the greatest depth of body; anterior with five to seven radial ribs, the bases of which may be connected by reticulation; posterior with nine to ten usually simple ribs. Left sulcal list usually ends at or somewhat ventrally to antapex but may extend somewhat farther; with *two* lobes, one of which is posteroventral, the other posterior; width at posteroventral lobe 0.56–1.06, at posterior lobe 0.54–1.06 the greatest depth of body; lobes narrowly rounded to subacute, large to fairly small; distance between their tips 0.81–1.41 the greatest depth of body; dorsal margin straight, or gently convex or concave; with three to six radial ribs and submarginal rib behind fission rib. Length, 27.4–34.0 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — This is a small species, obliquely subellipsoidal or subrotund in lateral outline, widest near the middle. The ratio between the length and the depth of the body is 1.04 (0.99–1.08) : 1. The longitudinal axis is deflected posterodorsally at 10° (5°–20°).

The epitheca is 0.37 (0.28–0.45) as deep as the hypotheca, gently convex, highest in or near the center, and subhorizontal or but slightly tilted ventroposteriorly. The transverse furrow is gently convex or flat; its dorsal width is 0.38 (0.36–0.42) the greatest depth of the body; its ventral width is 0.57 (0.50–

0.66) its dorsal width. The posterior cingular list is 0.23 (0.19–0.26) the length of the body from the apex. The dorsal, posterior, and ventral margins of the hypotheca are well rounded and confluent; or any of them may be slightly flattened. When seen in dorsoventral view, the body is broadly ellipsoidal and widest near the middle; the anterior end is almost as broadly rounded as the posterior; the ratio between the length and the width is 1.14: 1.

The anterior cingular list is 0.56 (0.48–0.68) the greatest depth of the body and has an anterior inclination of 30° (25°–40°); it has on each valve five to seven complete radial ribs, the bases of which may be connected by reticulation. The posterior cingular list is 0.48 (0.37–0.60) the greatest depth of the body and is inclined anteriorly at 60° (55°–75°); it has on each valve nine to ten complete, subequidistant radial ribs, which usually are simple, but some of which may be proximally branched or connected by reticulation. The right sulcal list is of moderate size and ends near the fission rib of the left sulcal list; it either is subtriangular, decreasing gradually in width posteriorly, or it is of subuniform width throughout the greater portion of its length and gently rounded posteriorly. The left sulcal list usually ends at or somewhat ventrally to the antapex of the body, but it may extend somewhat farther (Jörgensen, 1923, fig. 54). It has *two* narrowly rounded to subacute lobes, one posteroventral, the other posterior, and these usually are of moderate size but may be fairly small to quite large. The width of this list at the anterior main rib is 0.49 (0.36–0.60), at the fission rib 0.46 (0.32–0.54), at the posteroventral lobe 0.80 (0.56–1.06), at the narrowest place between the lobes 0.46 (0.24–0.61), and at the posterior lobe 0.76 (0.54–1.06) the greatest depth of the body. The distance between the tips of the lobes is 1.13 (0.81–1.41) the greatest depth of the body. The margin of this list between the anterior main rib and the tip of the posteroventral lobe may be nearly straight, but usually it is gently concave. Between the tips of the lobes the margin is moderately concave in most specimens, but it may be slightly or strikingly concave. The dorsal margin of this list is straight, or gently convex or concave. In front of the fission rib this list generally has one or two ribs; when two ribs are present, they may either be simple, or they may anastomose, and their bases may be connected by reticulation. Behind the fission rib there are three to six simple radial ribs, the tips of which are connected by a submarginal rib. The submarginal rib extends to the fission rib, which it joins at any point between the tip and the base (Figure 75: 1, 2, 4). The radial ribs may be furnished with very short branches (Figure 75: 1); and some of them may not quite reach the submarginal rib. Reticulations have not been found behind the fission rib.

The thecal wall is porulate with evenly distributed pores; these may either be all alike, or one in six or eight may be darker than the others. Sometimes areolation is developed of about the same type as in *Ornithocercus carolinae*. Fairly large phaeosomes have been observed in the transverse furrow.

The dimensions of seven of our specimens, including the type, and of the specimen figured by Jörgensen (1923, fig. 54) were measured.

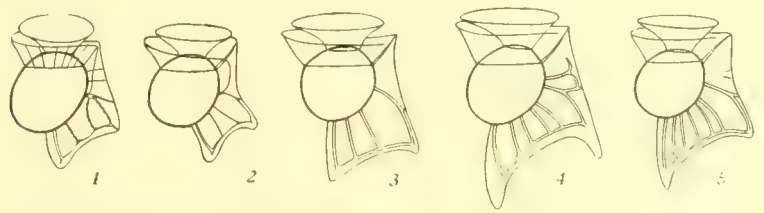

FIGURE 75.— *Ornithocercus heteroporus* Kofoid, right lateral view, illustrating variations in the shape and structure of left sulcal list. × 340. 1, from Station 4681 (300–0 fathoms); 2, from Station 4732 (300–0 fathoms); 3, from Station 4722 (300–0 fathoms); 4, from Station 4734 (300–0 fathoms); 5, from Station 4737 (300–0 fathoms).

Dimensions: — Our specimens: Length of body, 27.4–34.0 μ (average, 30.2 μ; type, 27.7 μ). Greatest depth of body, 25.7–31.4 μ (average, 28.9 μ; type, 25.7 μ). Jörgensen's (1923) specimens were 32–34 μ long and 31–32 μ deep.

Variations: — While the size of the body and the size and shape of the cingular lists are quite constant, the shape and structure of the left sulcal list are subject to considerable variations. The two lobes of the left sulcal list sometimes (Figure 75: 4) are very large, sometimes of moderate size (Figure 75: 1). The number of radial ribs in this list behind the fission rib ranges from three (Figure 75: 1–3) to six (Figure 75: 5). The shape of the body also exhibits some variability; usually it is obliquely subellipsoidal, but it may be subrotund (Figure 75: 3).

Comparisons: — Our description and figures are based on the type material. The specimen figured by Jörgensen (1923, fig. 54) agrees so closely with some of our typical representatives of this species (Figure 75: 3) that its allocation may be considered as certain. This species, as conceived in the present paper, includes specimens of quite different habitus, and its systematic unity may appear somewhat questionable. That these specimens have been lumped together is due to the fact that their variation seems to be continuous.

The small size, the shape of the body, and the fact that the left sulcal list usually ends at or somewhat ventrally to the antapex of the body indicate that this species is fairly low in the evolutionary scale of this genus. Its closest relative possibly is *Ornithocercus splendidus*, which it resembles in the shape of the body

and in having a two-lobed left sulcal list usually ending at or somewhat ventrally to the antapex. These two species are easily distinguished from each other by the width of the cingular lists and by the structure of the left sulcal list. *O. splendidus* has much more highly elaborated and expanded lists, though of the same fundamental type.

Synonymy: — This species was established by Kofoid (1907a) under the name of *Ornithocercus heteroporus*, a name also used by Jörgensen (1923).

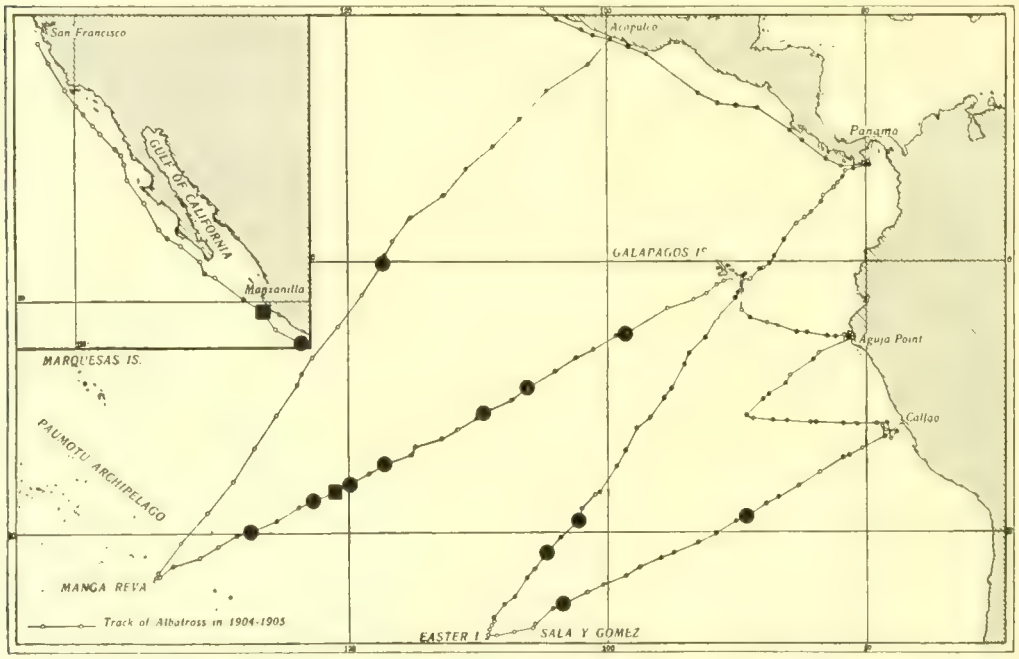

FIGURE 76.— Occurrence of *Ornithocercus heteroporus* Kofoid. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls (Salpa); small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

Occurrence: — *Ornithocercus heteroporus* is recorded at fifteen of the 127 stations. There are 2, 0, 2, 2, 8, and 1 stations on the six lines of the Expedition. Of these fifteen stations, two (4588, 4590) are in the Mexican Current; two (4691, 4699) are in the Easter Island Eddy; ten (4681, 4701, 4717, 4722, 4724, 4730, 4732, 4733, 4734, 4737) are in the South Equatorial Drift; and one (4742) is in the South Equatorial Current. At two stations (4588, 4733), the species was found in stomachs of Salpa taken in surface waters; all the other records refer to hauls from 300–0 fathoms.

The temperature range of these fifteen stations at the surface was 68°–83°; the average was 77.3°.

The frequency is in all cases less than 1%.

This species was first recorded by Kofoid (1907a) from Station 4699 of the Expedition, which thus is the type locality. Later Jörgensen (1923) found it to be widely spread in the Mediterranean and he also recorded it from the Bay of Cadiz, from a station "south-southeast of St. Helena," from the Guinea Current, and from off the southeast coast of Arabia.

This is probably a eupelagic, stenothermal, and warm-water species, widely distributed but rare in tropical, subtropical, and warm-temperate seas. Its absence from the California Current, Panamic Area, and Peruvian Current as well as its rare occurrence in the Mexican Current, according to our data, are noteworthy. Its prevalence in deeper waters should also be observed.

Ornithocercus splendidus Schütt

Plate 16, fig. 2, 4; Plate 17, fig. 3. Figure 77, 85: 3, 78

Ornithocercus splendidus Schütt, 1893, p. 272, fig. 82 (as *Ornithocerus splendidus* in fig. 83); 1895, p. 19, 130, 131, 150, pl. 5, fig. 22; 1899, p. 14, 16, 50, pl. 6, fig. 11; 1900a, p. 9, 20, fig. 11. Hensen, 1895, p. 189; 1911, tab. 15. Karsten, 1906, pl. 187; 1907, p. 240, 247, 248, 249, 253, 256, 268, 272, 273, 274, 276, 287, 292, 294, 295, 296, 298, 299, 301, 303, 304, 305, 306, 309, 310, 311, 312, 316, 318, 319, 336, 338, 340, 347, 348, 351, 353, 354, 355, 356, 357, 427, 471, 473. Doflein, 1909, p. 457, fig. 404A; 1911, p. 522, fig. 463A; 1916, p. 423, fig. 375A. Stüwe, 1909, p. 236, 237, 254, 288. Steuer, 1910, p. 197, fig. 107; 1911, p. 103, fig. 83. Nathansohn, 1910b, p. 60, 62, fig. 30. Carisso, 1911, p. 89. Effenberger, 1911, fig. 27: B. Hjort, 1911, pl. 367, fig. 11: 5. Gran, 1912a, p. 935, fig. 7a; 1912b, p. 328, 329, fig. 234a. Stiasny, 1913, p. 46, 77, fig. 12. Francé, 1923, fig. 11: 5. Lindemann, 1924, p. 10; 1925, p. 96.

Ornithocercus splendens Schütt, 1896, pl. 29, fig. 41B. Gräf, 1909, p. 138, 149, 165, 173, 176, 179, 184, 186, 188.

Histioneis splendida Murray & Whitting, 1899, p. 332, tab. 3, 68, pl. 32, fig. 1a–c. Lemmermann, 1899a, p. 320, 374; 1901a, p. 377. Schröder, 1906a, p. 329. Gadeceau, 1909, pl. 9, fig. "2 en haut."

Histioneis splendidus Cleve, 1901c, p. 252; 1902b, p. 32.

Ornithocercus magnificus, Doflein, 1909, p. 465, fig. 417: 8; 1911, p. 531, fig. 478: 8; 1916, p. 436, fig. 396: 8. Oltmanns, 1922, fig. 38: 8.

Ornithocerus splendidus Théel, 1909, p. 239, fig. 39.

Diagnosis: — Lateral outline subobovate, subellipsoidal, subcircular, subtriangular, or subtrapeziform. Cingular lists are huge: anterior 0.77–1.46, posterior 0.81–1.41 the greatest depth of body; both with 6–24 complete, sometimes irregular ribs, connected by more or less developed anastomoses. Left sulcal list ends at or somewhat ventrally to antapex; with two lobes, one of which is posteroventral, the other posterior; width at posteroventral lobe 0.96–1.92, at posterior lobe 0.80–1.53 the greatest depth of body; lobes narrowly rounded distally, and sometimes long and narrow, sometimes small; distance between their tips 0.82–2.07 the greatest depth of body; dorsal margin straight, moderately convex or concave, or sigmoid; with two to five, often incomplete, ribs behind fission rib; reticulations in lobes and often at tip of fission rib and between lobes. Submarginal rib usually absent. Length of body, 37.7–114.0 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — This species is usually medium-sized but may be fairly small or very large. The shape of the body in lateral outline is quite variable: sometimes it is subsymmetrically or obliquely subobovate, sometimes subrotund or obliquely subellipsoidal, sometimes rounded subtriangular or rounded subtrapeziform; and these various shapes are connected by transitions. The greatest depth is located at or somewhat behind the posterior cingular list, or near the middle of the body. The ratio between the length and the depth of the body is 1.05 (0.76–1.24) : 1. In our material two groups can be distinguished: one in which the body is deep (ratio 0.76–0.85: 1), the other with the body of moderate depth (ratio 1.04–1.24: 1). The longitudinal axis may be perpendicular to the posterior cingular list, but usually it is somewhat deflected posterodorsally; the maximum deflection as yet observed is about 20°; the average deflection is 10°.

The epitheca is 0.68 (0.50–0.88) as deep as the hypotheca, usually gently convex, but sometimes flat or strongly convex, highest in, or dorsally or ventrally to, the center, and subhorizontal. The transverse furrow is flat or gently convex; its dorsal width is subequal to or but slightly greater than the ventral, and 0.22 (0.11–0.28) the greatest depth of the body. The posterior cingular list is 0.30 (0.17–0.40) the length of the body from the apex. The dorsal, posterior, and ventral margins of the hypotheca are confluent, and any one of them may be somewhat flattened. When seen in dorsoventral view, the body is regularly obovate, widest at or somewhat behind the posterior cingular list; the ratio between the length and the width is 1.4–1.7: 1.

The cingular lists are wider relatively than in any other known species and resemble a pair of everted parachutes. The anterior of them is 1.17 (0.77–1.46), the posterior 1.15 (0.81–1.41) the greatest depth of the body; both have an anterior inclination of 30°–50°, and both are furnished with 6–24 complete radial ribs, which are connected by more or less developed anastomoses, and which may be quite irregular. The right sulcal list, which is small, ends somewhere between the fission rib of the left sulcal list and the second rib behind the fission rib. It either is subtriangular, decreasing gradually in width posteriorly; or it is of subuniform width throughout the greater portion of its length and strongly rounded or rounded subrectangular (Plate **17**, fig. 3) posteriorly. Its width in the middle is 0.14–0.20 the greatest depth of the body; and it may be furnished with one to several, regular or more or less irregular ribs. The left sulcal list, which ends at or somewhat ventrally to the antapex of the body, has two lobes, one of which is posteroventral, the other posterior in position. At the posteroventral lobe the

width of this list is 1.40 (0.96–1.92), at the posterior lobe 1.23 (0.80–1.53) the greatest depth of the body; at the anterior main rib and between these two lobes the corresponding values are 0.75 (0.67–1.00) and 0.74 (0.48–0.93), respectively. The two lobes are narrowly rounded distally, and sometimes long and narrow, sometimes small. The distance between their tips is 1.38 (0.82–2.07) the greatest depth of the body. The margin between the anterior main rib and the tip of the posteroventral lobe may be almost straight, but usually it has a more or less pronounced concavity. The concavity between the two lobes sometimes is rather shallow, sometimes it is very deep. The dorsal margin of this list is nearly straight in some specimens, in others it is gently concave, moderately convex, or strikingly sigmoid. There are two to five radial ribs behind the fission rib. These ribs usually are simple, straight or gently curved, and the posterior ends either in or somewhat ventrally to the posterior lobe. Some may extend to the margin of the list, but most of them usually end before the margin is reached. The posterior one may have a dorsal branch near its base (Murray and Whitting, 1899, pl. 32, fig. 1a). A submarginal rib may be present between the two lobes (Figure 85: 3). More or less developed reticulation is to be found in the two lobes, at the end of the fission rib, and sometimes at the end of one of the ribs ending between the lobes. In front of the fission rib this list has one to three ribs.

The thecal wall has numerous pores; on the hypotheca each of these sometimes is surrounded by a small areole. Near the middle of the body there are about 10–15 pores across the face of each valve. We have no record of the presence of phaeosomes.

The dimensions of twenty of our specimens and of the specimen figured by Murray and Whitting (1899, pl. 32, fig. 1) were measured.

Dimensions: — Our specimens: Length of body, 37.7–49.8 μ (average, 43.2 μ). Greatest depth of body, 32.9–62.2 μ (average, 43.3 μ). In our large specimens the greatest depth is 43.0–62.2 μ (average, 57.5 μ); in our small specimens it is 32.9–39.2 μ (average, 35.6 μ). The type specimen, according to Schütt (1893, fig. 83), was about 114 μ long. The specimen figured by Murray and Whitting (1899, pl. 32, fig. 1a) was 87.2 μ long and 84.0 μ deep.

Variations: — This species shows a pronounced variability in most of its characters. The length of the body varies from 37.7 to 114.0 μ. In our material two very distinct size-groups can be distinguished; in one of these the body is very deep (43.0–62.2 μ; average, 57.5 μ), in the other it is of moderate depth (32.9–39.2 μ; average, 35.6 μ). The shape of the body is also subject to striking variations; sometimes it is subsymmetrically (Plate 16, fig. 4) or obliquely (Figure

77:8) subobovoidal, sometimes subrotund (Figure 77:4), sometimes obliquely subellipsoidal (Figure 77:3), sometimes rounded subtriangular (Figure 77:11), sometimes rounded subtrapeziform (Figure 77:9, 10), and these various forms are

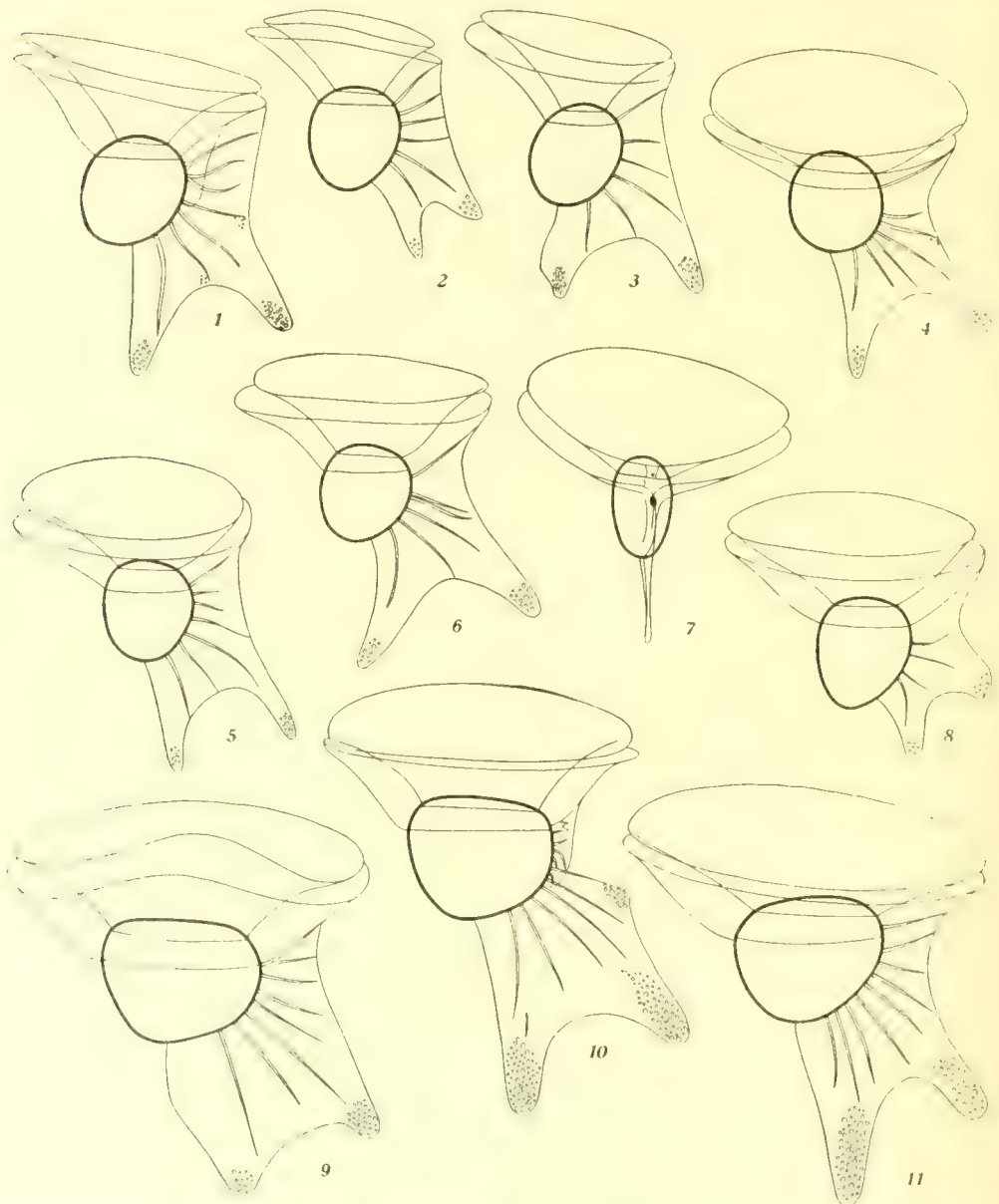

FIGURE 77.— *Ornithocercus splendidus* Schütt. 1–6, 8–11, in right lateral view; 7, in ventral view, illustrating variations in size of body and in shape and structure of left sulcal list. × 340. 1, 2, 3, 5, 6, 7, from Station 4737 (300–0 fathoms); 4, from Station 4737 (100–0 fathoms); 8, from Station 4730 (300–0 fathoms); 9, 11, from Station 4740 (300–0 fathoms); 10, from Station 4695 (300–0 fathoms).

connected by transitions. Both the cingular lists may have relatively few (Plate 16, fig. 2) or numerous (Schütt, 1893, fig. 82) radial ribs. The development of the anastomoses connecting these ribs also varies; compare our Plate 17, figure 3,

and Schütt's (1893) figure 82. The left sulcal list, which sometimes ends at, sometimes ventrally to the antapex of the body, varies in size, shape, and structure. In some specimens it is comparatively narrow (Figure 77: 8), in others wide (Figure 77: 10, 11). Its two lobes may be short (Figure 77: 8, 9), or long and narrow (Figure 77: 5, 11). The concavity between these lobes may be relatively shallow (Figure 77: 9) or deep (Figure 77: 5), narrow (Figure 77: 2) or wide (Figure 77: 6). The dorsal margin of this list is nearly straight in some specimens (Figure 77: 1), but it may be gently concave (Figure 77: 6), moderately convex (Plate 17, fig. 3), or strikingly sigmoid (Figure 77: 3). The number of the radial ribs behind the fission rib ranges from two to five (Figure 77: 2, 10), and their shapes also vary. A submarginal rib may be present between the two lobes (Figure 85: 3); and the reticulation in these lobes shows various degrees of development. The eleven specimens represented by Figure 77, Figure 85: 3, Plate 16, figure 2, 4, and Plate 17, figure 3, illustrate the range of variation exhibited by this species in the material of the Expedition. Unfortunately, we are not able to give the relative frequency of these various forms, since only twenty of our specimens were subjected to a careful study.

Comparisons: — In spite of the fact that Schütt (1893) figures the type specimen of *Ornithocercus splendidus* from the ventral and posterior sides only and our knowledge of its structure thus is quite incomplete; and in spite of the apparent striking difference in size (114.0 μ as compared to 37.7–49.8 μ) between this specimen and the specimens from the material of the Expedition assigned in the present paper to this species, this allocation of ours may be regarded as fairly certain. The dimensions of Schütt's (1893) specimens are from a single specimen, and are based on his stated magnification (250 diameters). If we utilize another magnification (650 diameters) based on his figures, the dimensions of his specimen will fall within ours. The specimen figured by Murray and Whitting (1899, pl. 32, fig. 1) agrees closely with some of our specimens except in size (the length of its body being 87.2 μ as compared to 37.7–49.8 μ) and in the fact that the posterior rib of its left sulcal list has a short, reticulated branch near the base. A similar shift in the magnification cited by Murray and Whitting (1899) from 310 to 620 brings his specimen within our dimensions.

The species, as conceived in the present paper, is strikingly variable. We have considered it most advisable to treat these various forms as belonging to a single systematic unit for the following reasons. (*1*) Striking differences in size, if such exist, are characteristic of several species of this genus, and small specimens are known sometimes to arise from large by rapidly succeeding fissions (Plate 18,

fig. 2, 7). Our large specimens evidently were in the megacytic stage. (*2*) The structure of the cingular lists, and the size, shape, and structure of the left sulcal list are subject to pronounced variations in other species of this genus, *e.g.*, in *Ornithocercus steini* and *O. thurni*. Furthermore, these variations evidently are partly due to differences in age and to adaptive regulation. (*3*) The variations are apparently continuous, with the exception of those in size.

Ornithocercus splendidus occupies a rather isolated position; indeed, Murray and Whitting (1899, p. 332) established it as the sole member of a new subgenus, Paraschüttia. We do not know which of the other known species of this genus is its closest relative. It may be mentioned, however, that *O. heteroporus* resembles it in having a two-lobed left sulcal list usually ending at or somewhat ventrally to the antapex of the body. *O. splendidus* differs strikingly from *O. heteroporus* in its larger size and in having the cingular list very wide and structurally highly differentiated. The similarity between *O. splendidus* and *O. quadratus* f. *intermedia* should also be observed.

Synonymy: — This species was established by Schütt (1893) under the name of *Ornithocercus splendidus*, a specific name also used by most of the other investigators who have treated this form. Schütt's (1896) name *O. splendens*, evidently due to a slip of the pen, was applied to this species by Gräf (1909). In Doflein (1909, 1911, 1916) and Oltmanns (1922) this form is figured as *O. magnificus*, a typographical error. Murray and Whitting (1899), Lemmermann (1899a, 1901a), Cleve (1901c, 1902b), Schröder (1906a), and Gadeceau (1909) use Histioneis as the generic name of this species. Reproductions of Schütt's (1893) figures of the type specimen are found in Schütt (1896), Doflein (1909, 1911, 1916), Théel (1909), Nathansohn (1910b), Steuer (1910, 1911), Effenberger (1911), Stiasny (1913), Oltmanns (1922), and Francé (1923). Reproductions of Murray and Whitting's (1899) figures are given by Gadeceau (1909), Hjort (1911), and Gran (1912a, b).

Occurrence: — *Ornithocercus splendidus* is recorded at thirty-five of the 127 stations. There are 2, 1, 8, 8, 11, and 5 stations on the six lines of the Expedition. Of these thirty-five stations, one (4583) is in the California Current; one (4587) is in the Mexican Current; one (4613) is in the Panamic Area; one (4676) is in the Peruvian Current; five (4689, 4691, 4695, 4697, 4699) are in Easter Island Eddy; twenty-two (4679, 4681, 4683, 4685, 4687, 4701, 4702, 4705, 4707, 4709, 4717, 4721, 4722, 4724, 4728, 4730, 4732, 4734, 4736, 4737, 4739, 4740) are in the South Equatorial Drift; three (4742, 4743, 4540) are in the South Equatorial Current; and one (4541) is in the Equatorial Counter Current. At four stations (4702,

4743, 4540, 4541) the species was taken in surface waters only; at one station (4737) in a haul from 100–0 fathoms as well as in a haul from 300–0 fathoms; at eight stations (4681, 4689, 4701, 4721, 4724, 4728, 4732, 4740) in hauls from both 800–0 fathoms and 300–0 fathoms. All the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these thirty-five stations at the surface was 68°–83°; the average was 75.8°. At the four stations in the surface catches of which this species was found, the surface temperature ranged from 73° to 80°; the average was 77.5°.

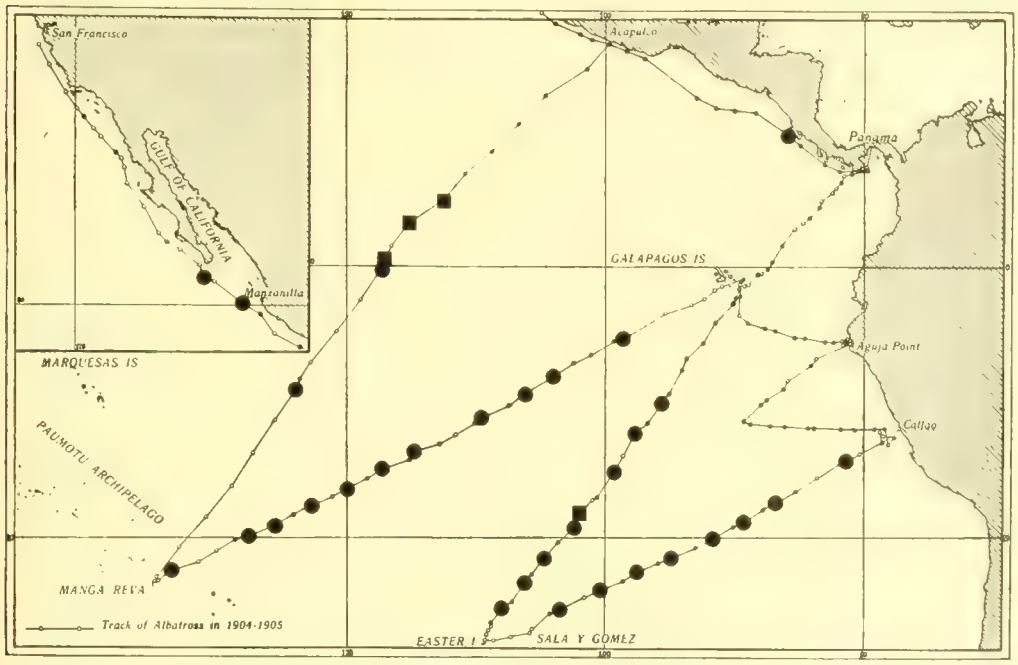

FIGURE 78.— Occurrence of *Ornithocercus splendidus* Schütt. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

At one of the surface stations (4541) the frequency was 1%; at the remaining surface stations it was less. For the catches from 100, 300, or 800 fathoms to the surface the records of frequency are as follows: 4% at one station (4724); 3% at two stations (4681, 4739); 2% at five stations (4689, 4697, 4737, 4740, 4742); 1% at eight stations (4683, 4685, 4687, 4695, 4701, 4722, 4728, 4732); at the remaining stations the frequency is less than 1%.

The type specimen of this species (Schütt, 1893) was probably taken in the tropical or in the subtropical region of the Atlantic Ocean. Later investigators have shown it to be widely distributed. The following authors have found it in the Atlantic, between lat. 41° N. and lat. 21° S. :— Hensen (1895, 1911), Murray

and Whitting (1899), Lemmermann (1899a), Cleve (1901c, 1902b), Karsten (1906), Stüwe (1909), and Gräf (1909). It has been recorded from the Gulf of Naples by Lindemann (1924, 1925). In the Red Sea and the Gulf of Aden it was found by Karsten (1907); in the Indian Ocean, by Schröder (1906a), Karsten (1907), and Gräf (1909).

Most of the records referred to in the last paragraph were from surface hauls. The only records of closing-net hauls published as yet are the following by Karsten (1907): — Station 182, lat. 10° 8′ S., long. 97° 14′ E., 200–100 m., dead; Station 229, lat. 2° 38′ S., long. 63° 37′ E., 600–400 m. and 200–20 m., no statement as to condition of specimens; Station 268, lat. 9° 6′ N., long. 53° 41′ E., 80–67 m., living; 105–88 m., dead.

According to the authors mentioned in the next but last paragraph, this species occurs in waters of the following temperatures and salinities.

	Temperature	Range	Number and Mean of Observations	Salinity Range	Number and Mean of Observations
Murray and Whitting (1899)		64°–84°	11 73.6°		
Cleve (1901c)		62.2°–81.0°	24 70.7°	33.88–37.21	16 36.24
Cleve (1902b)	65.3°				4 35.37
Stuwe (1909)	68.6°				
Gräf (1909)		81.5°–84.2°			

Of the investigators who have contributed to our knowledge of the distribution of this species only Schütt (1893) and Murray and Whitting (1899) give figures by means of which their determinations may be checked.

Ornithocercus splendidus is eupelagic and widely distributed in tropical and subtropical seas. In most cases it is rare, but sometimes (Gräf, 1909, p. 173) it is fairly common. In the Eastern Pacific it occurs in the whole area investigated by the Expedition, but it is strikingly rare in the Mexican Current, Panamic Area, and Peruvian Current, and is not recorded from the northern portion of the California Current; however, it occurs occasionally as far to the north as at San Diego. Another striking feature about the distribution of this species, according to our data, is its rare occurrence in surface waters (four stations out of 35).

2. Magnificus Group. All the species belonging to this group were found in the material of the Expedition. They have been treated in this paper in the following order, indicative of relationships: — *Ornithocercus magnificus s. str.*, *O. thurni*, *O. steini s. str.*, *O. orbiculatus*, *O. quadratus*, and *O. carolinae*.

Ornithocercus magnificus Stein, *s. str.* Schütt

Plate 16, fig. 3. Figure 79, 80

Ornithocercus magnificus Stein, 1883, *partim*, pl. 23, fig. 1, 2. Chun, 1886, p. 58. Daday, 1888, p. 99. Schütt, 1895, p. 112, 136, 138, pl. 4, fig. 21: 9, pl. 5, fig. 21: 1, 3–8; 1895, pl. 5, fig. 21: 2(?); 1896, p. 29, fig. 41A; 1899, p. 14, 16, pl. 6, fig. 7, 12(?); 1900a, p. 9, 16, 18, fig. 8–10. Hensen, 1895, p. 189; 1911, p. 137, 138, 163, 393, tab. 15. Cleve, 1897a, *partim*, p. 26, tab. 1. Ostenfeld, 1898a, p. 428; 1915, p. 7. Ostenfeld & Schmidt, 1901, p. 173. Schmidt, 1901, p. 138. Lohmann, 1902, p. 53; 1908a, p. 168, 169; 1920, p. 484, 492, 539, 545, 547, 565. Entz, 1902a, p. 122. Zacharias, 1906, p. 509, 518, 530, 531, 532, 534, 536, 552, 557, 566, 569; *non* 1906a, p. 274, fig. 7; *non* 1907, fig. 14; *non* 1911, fig. 51. Karsten, 1906, p. 180, 181, 182, 183, 187, 189, 190, 191, 200, 201, 202, 204, 205, 207; 1907, p. 236, 238, 240, 241, 243, 245, 246, 247, 248, 249, 250, 253, 254, 255, 256, 258, 259, 260, 263, 265, 267, 268, 269, 270, 271, 274, 275, 276, 277, 279, 283, 289, 290, 291, 292, 295, 297, 298, 300, 304, 305, 308, 311, 313, 314, 315, 316, 317, 321, 322, 323, 324, 325, 330, 331, 332, 333, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 352, 353, 354, 355, 356, 357, 358, 427, 440, 445, 450, 471. Schröder, 1906a, p. 321, 322, 323, 325, 326, 329, 335; 1911, p. 15, 18. Kofoid, 1907a, p. 205, 206; 1911, p. 237. Okamura, 1907, p. 132, *partim*(?); 1912, p. 20. Doflein, 1909, p. 465, fig. 417: 7 (*non* 417: 8); 1911, p. 531, fig. 478: 7 (*non* 478: 8); 1916, p. 436, fig. 396: 7 (*non* 396: 8). Gräf, 1909, p. 173. Schiller, 1912, p. 27; 1912a; 1914, p. 14. Gran, 1912b, p. 328, 330, fig. 235. Faria & Cunha, 1917, *partim*, p. 79. Oltmanns, 1922, fig. 38: 7 (*non* fig. 38: 8). Jörgensen, 1923, p. 35, 36, 37, 44, fig. 48. Lindemann, 1924, p. 7 (*non* p. 5).

non *Ornithocercus magnificus* Bütschli, 1885, pl. 55, fig. 7. Chun, 1903, p. 75, fig. b. Whitelegge, 1891, p. 185. Fricke, 1902, p. 55. Willey & Hickson, 1909, p. 184, fig. 8. Hjort, 1911, p. 367, fig. 12: 4. Francé, 1923, fig. 11: 2.

Histioneis magnifica Murray & Whitting, 1899, *partim*, p. 332, 333, tab. 1–9. Entz, 1902b, p. 94; 1905, p. 112. Pavillard, 1905, *partim*, p. 60, 81, 102; 1916, *partim*, p. 61. Meunier, 1910, p. 59. Issel, 1921, p. 17. Forti, 1922, *partim* (?), p. 113, 192, 209, 213, pl. 7, fig. 124.

Histioneis magnificus Lemmermann, 1899a, *partim*, p. 319, 320, 323, 330, 331, 332, 374; 1901a, *partim*, 376; 1905a, p. 37 (as *H. magnifica*). Cleve, 1900b, *partim*, p. 1031; 1901a, p. 16; 1901c, p. 250 (as *H. magnifica*); 1902b, p. 32 (as *H. magnifica*); 1903b, p. 345 (as *H. magnifica*). Cleve, Ekman, & Pettersson, 1901, *partim*, p. 16, tab. 2.

non *Histioneis magnificus* Lemmermann, 1899a, p. 317, 323, 327.

non *Histioneis magnifica* Schröder, 1900a, p. 20, pl. 1, fig. 15.

Ornithoceras magnificus Gräf, 1909, p. 139.

Ornithocercus magnificus, var. *a*, Stüwe, 1909, p. 237, 243, 244, 254, 275, 288, pl. 2, fig. 21.

Ornithocercus minor Jörgensen, 1923, p. 35.

Diagnosis: — Subcircular in lateral outline. Cingular lists: anterior 0.51–0.92, posterior 0.48–0.68 the greatest depth of body; anterior with four to nine simple, complete, and some incomplete ribs; posterior with twelve to seventeen simple, complete, and some incomplete ribs. Left sulcal list ends on dorsal side of body at 0.33–0.60 the greatest depth of body from posterior cingular list; with three narrowly rounded lobes, one of which is posteroventral, one antapical, and one posterodorsal; width at posteroventral lobe, 0.72–1.33, at antapical lobe 0.64–1.19, and at posterodorsal lobe 0.66–1.19 the greatest depth of body; typically with five ribs behind fission rib; distal ends of these ribs and fission rib connected by submarginal rib; with reticulum in each of the three lobes; *a*-rib extends into posterodorsal lobe; *b*- and *c*-ribs usually end dorsally to vertex of midlobe, *d*- and *e*-ribs dorsally to posteroventral lobe. Length of body, 31.9–46.6 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — This species is fairly small or medium-sized, subcircular in lateral outline, and deepest in or near the middle. The ratio between the length and the depth of the body is 0.94–1.13: 1; in our specimens this ratio is 1.01 (0.94–1.12): 1. The longitudinal axis may be perpendicular to the posterior cingular list, but usually it is deflected posterodorsally at 7° (1°–10°).

The epitheca is 0.47 (0.37–0.56) as deep as the hypotheca, slightly convex or flat, highest in or somewhat dorsally to the center, and somewhat tilted ventroposteriorly. The transverse furrow usually is somewhat concave but may be almost flat; its dorsal width is 0.38 (0.34–0.42) the greatest depth of the body; its ventral width is 0.52 (0.44–0.62) its dorsal width. The posterior cingular list is 0.26 (0.20–0.30) the length of the body from the apex. The dorsal, posterior, and ventral margins of the hypotheca are confluent; the dorsal may be somewhat flattened (Figure 79: 4).

The anterior cingular list is 0.51–0.92 the greatest depth of the body and has an anterior inclination of 40° (35°–45°); in our specimens its width is 0.63 (0.51–0.79); it has on each valve four to nine simple and complete ribs and between these a varying number of incomplete ribs; and it may be reticulated basally (Stein, 1883, pl. 23, fig. 1). The posterior cingular list is 0.56 (0.48–0.68) the greatest depth of the body and is inclined anteriorly at 60° (45°–80°); it has on each valve 12–17 complete, simple, and subequidistant ribs and may have the same number of incomplete ribs (Plate **16**, fig. 3). The right sulcal list is relatively small and subtriangular or rounded triangular, decreasing gradually in width posteriorly; it usually extends to or somewhat beyond the fission rib of the left sulcal list but may be somewhat shorter (Plate **16**, fig. 3). The left sulcal list ends on the dorsal side of the body at a distance from the posterior cingular list equaling 0.50 (0.33–0.60) the greatest depth of the body and is characterized by three narrowly rounded posterior lobes, one of which is posteroventral, one antapical (the middle one), and one posterodorsal. In our specimens the width of this list at the anterior main rib is 0.53 (0.42–0.64), at the fission rib 0.55 (0.40–0.64), at the posteroventral lobe 0.88 (0.72 1.21), at the antapical lobe 0.79 (0.64–1.04), and at the posterodorsal lobe 0.83 (0.66–1.13) the greatest depth of the body. In the specimens figured by Stein (1883, pl. 23, fig. 1, 2), which have this list somewhat wider than any other figured specimens, the corresponding values are: — 0.51–0.65, 0.62–0.65, 1.33, 1.15–1.19, and 1.15–1.19. The ventral margin of this list is almost straight, gently concave or convex, gently sigmoid, being concave anteriorly and convex posteriorly, or slightly irregular. Between the tips of the antapical lobe and the tips of the posteroventral and posterodorsal lobes, the

posterior margin is gently or more or less strikingly concave (Figure 79: 5; Plate **16**, fig. 3). The dorsal margin is gently convex. Between the anterior main rib and the fission rib this list may have one or a few ribs (Stein, 1883, pl. 23, fig. 2). Behind the fission rib this list typically (Figure 79: 3) has five radial ribs connected distally by a submarginal rib. The submarginal rib extends along the whole posterior margin of the list and from the posteroventral lobe to the fission rib with which it is connected; in the tip of each of the three posterior lobes it usually forms a reticulum (Plate **16**, fig. 3); sometimes (Stein, 1883, pl. 23, fig. 2) it is incomplete. Of the five radial ribs the *a*-rib (the dorsal rib) extends into the posterodorsal lobe; the *b*- and *c*-ribs usually end dorsally to the vertex of the antapical (middle) lobe, but the *c*-rib may join the submarginal rib just in front of this point (Jörgensen, 1923, fig. 48); the *d*- and the *e*-ribs always join the submarginal rib dorsally to the posteroventral lobe. In our specimens the lengths of the main radial ribs, measured to the points where these ribs join the submarginal rib, are as follows:— the *a*-rib is 0.65 (0.49–0.78), the *b*-rib 0.43 (0.33–0.51), the *c*-rib 0.50 (0.40–0.68), the *d*-rib 0.50 (0.37–0.63), and the *e*-rib 0.48 (0.34–0.58) the greatest depth of the body. Sometimes less than five main radial ribs are developed; sometimes one or a few accessory ribs are interpolated (Figure 79: 2, 5). These variations probably are due to age; the *a*- and the *d*-ribs usually are developed before the remaining ribs; the next to appear usually is the *c*-rib (Figure 79: 8, 7). Generally the radial ribs are simple; but in old specimens they may have short projections or be more or less branched, the branches in most cases anastomosing (Figure 79: 1, 2).

The whole thecal wall is porulate, that of the hypotheca is areolate. The areoles are of moderate and subuniform size (Plate **16**, fig. 3) or relatively small (Jörgensen, 1923, fig. 48), and each of them has a pore in the middle. Near the middle of the body there are on the average 13–20 areoles across the face of each valve. A row of 11–13 polygons, somewhat larger than the areoles, borders the girdle posteriorly. Phaeosomes are to be found in the transverse furrow.

The proportions of thirteen of our specimens and of the specimens figured by Stein (1883, pl. 23, fig. 1, 2), Schütt (1895, pl. 5, fig. 21: 4), and Jörgensen (1923, fig. 48) were measured.

Dimensions: — Our specimens: Length of body, 31.9–46.6 μ (average, 38.4 μ). Greatest depth of body, 33.4–47.4 μ (average, 38.5 μ). We do not know the size of the two specimens of this species figured by Stein (1883, pl. 23, fig. 1, 2), one of which is the type. According to Stein's (1883) information about the magnifications of his figures given in an introductory remark to the explanations

of the plates, these specimens were somewhere between 37.3 and 60.7 μ long; the type specimen (Stein, 1883, pl. 23, fig. 1) was somewhere between 39.5 and 60.7 μ. The specimen represented by Schütt's (1895) Plate 5, figure 21:4, was 42.6 μ long and 40.6 μ deep; the one figured by Jörgensen (1923, fig. 48) was 40.0 μ long and 40.0 μ deep. According to Zacharias (1906, p. 518) the length of the body is 40 μ.

Variations: — As conceived in the present paper, *Ornithocercus magnificus s. str.* is comparatively constant, except in the size of the body and in the size, shape, and structure of the left sulcal list. The first eight specimens of Figure 79

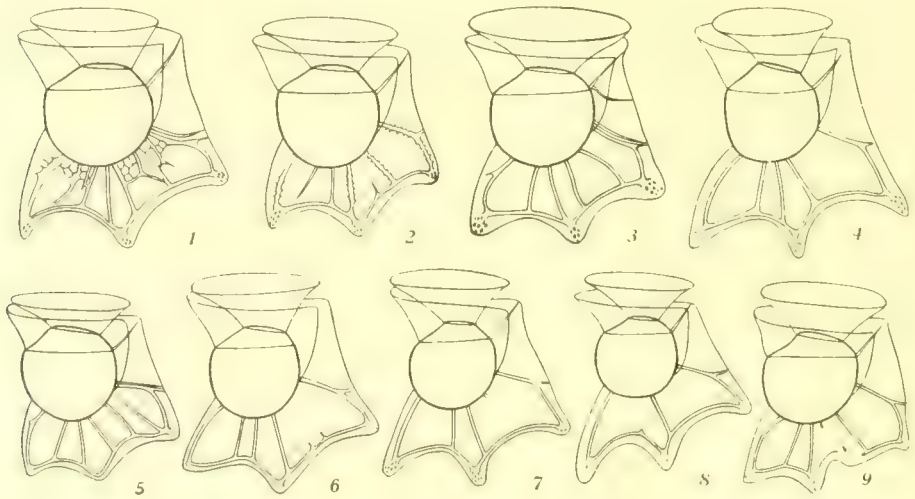

FIGURE 79.— *Ornithocercus magnificus* Stein, *s. str.*, right lateral view, illustrating variations in shape and structure of left sulcal list. × 340. 1, from Station 4742 (300–0 fathoms); 2, 5, from Station 4638 (300–0 fathoms); 3, from Station 4715 (300–0 fathoms); 4, from Station 4681 (300–0 fathoms); 6, from Station 4701 (300–0 fathoms); 7, from Station 4697 (300–0 fathoms); 8, from Station 4737 (300–0 fathoms); 9, from Station 4607 (300–0 fathoms).

cover fairly completely its range of variation as established from the material of the Expedition. The chief variations occur in the number and development of the radial ribs of the left sulcal list. In most of our specimens (186, *i.e.*, 62.0%, out of 300) these ribs agreed very closely with those of the specimen represented by Figure 79: 3; seventy-three specimens (24.3%) agreed with Figure 79: 4; twenty-two (7.3%) with Figure 79: 7; thirteen (4.3%) with Figure 79: 5; two (0.7%) with Figure 79: 8; each of the types shown in Figure 79: 1, 2, 6, was represented by only one specimen (0.3%). The specimens represented by Figure 79: 1, 2, probably were old, while Figure 79: 8 appears to represent a fairly young specimen, in which the structures of the right valve are still in a relatively undifferentiated condition following binary fission (compare Schütt, 1900a, fig. 8–10). The specimen represented by Figure 79: 9 should be considered as aberrant with

regard to the portion of the left sulcal list posteroventrally to the antapex of the body; probably this portion is in a condition of regeneration following a local injury. As an example of an old specimen in which the radial ribs of the left sulcal list are very heavy and furnished with anastomosing branches and numerous short projections, reference is made to Schütt (1900a, fig. 10). The *c*-rib of this list usually ends somewhat dorsally to the vertex of the middle lobe of this list (Figure 79; Schütt, 1900a, fig. 8–10), but it may join the submarginal rib just in front of this point (Stein, 1883, pl. 23, fig. 2; Jörgensen, 1923, fig. 48). The submarginal rib usually is well developed along the whole posterior margin of this list, but it may be partly absent (Schütt, 1900a, fig. 9). With regard to the specimen represented by Schütt (1895, pl. 5, fig. 21: 2), see the next section. The variations observed thus seem largely to be due to age, to irregularities in the regeneration of local injuries, or to resorption in adjustment to the requirements of flotation.

Comparisons: — Observations on a large number of specimens collected by the Expedition confirm the opinion of Schütt (1900a) that *Ornithocercus magnificus*, as conceived by Stein (1883), is heterogeneous (see the next section) and enable us to form a fairly good picture of *O. magnificus s. str.* Our specimens agree quite closely with those figured by Stein (1883, pl. 23, fig. 1, 2), Schütt (1895, pl. 5, fig. 21: 1, 4; 1900a, fig. 8–10), and Jörgensen (1923, fig. 48), and their specific unity appears to be beyond doubt. It should be observed in this connection that in the type specimen (Stein, 1883, pl. 23, fig. 1) the portion of the left sulcal list outside the submarginal rib has been omitted. The specimen represented by Schütt's (1895) Plate 5, figure 21: 2, differs strikingly from the typical specimens in the shape of the posterior margin of the left sulcal list and in the structure of this list between rib *a* and the fission rib. In spite of this, it has not been excluded from this species since the same radial ribs can be distinguished as in the typical specimens; we regard its aberrant structure as due to the same causes as in the case of the specimen represented by our Figure 79: 9.

No specimens have been found as yet which are distinctly intermediate between *Ornithocercus magnificus s. str.* and any of the other known species of this genus. Indeed, this species appears to occupy a somewhat isolated position. It is characterized especially by (*1*) its relatively small size; (*2*) its fairly small right sulcal list; (*3*) its three-lobed left sulcal list, which is furnished with five radial ribs behind the fission rib and with a submarginal rib, and (*4*) by the fact that in this list the *a*-rib extends into the dorsal lobe, the *b*-rib ends ventrally to the dorsal lobe, the *c*-rib somewhat dorsally to the vertex of the middle lobe, and the *e*-rib

usually somewhat dorsally to the vertex of the ventral lobe. Its closest-known relative probably is *O. thurni*, which also has a three-lobed left sulcal list furnished with five radial ribs behind the fission rib and with a submarginal rib. *O. thurni* is easily distinguished from this species by its larger size, its relatively large right sulcal list, and by the fact that the *c*- and *e*-ribs of the left sulcal list end at the vertices of the middle and ventral lobes. *O. magnificus* also resembles *O. carolinae* in possessing a three-lobed left sulcal list. The last species is readily recognized from the first by the dominating size of the middle of these three lobes and by having a greater number of radial ribs in the left sulcal list; it is probably not very closely related to *O. magnificus*.

Synonymy: — The synonymy of this species is so tangled that it probably will prove to be almost impossible to unravel. Under the name of *Ornithocercus magnificus*, Stein (1883, pl. 23, fig. 1–6) figured five specimens, belonging to three different species. Schütt (1900a, p. 16, 18), who was the first to point out the heterogeneity of this species as conceived by Stein, applied the name *magnificus* to the specimen represented by Stein's (1883) Plate 23, figure 1, which thus should be regarded as the type. We conclude that figure 2 of this plate also is referable to *O. magnificus s. str.* The specimen represented by Stein's (1883) Plate 23, figure 3, Schütt (1900a) made the type of a new species, *O. steini* [= *O. thurni*], to which also should be referred Stein's (1883) Plate 23, figure 5. Finally, Stein's (1883) Plate 23, figure 3, represents a specimen of *O. steini s. str.*, in which the lists have not yet attained their complete differentiation.

In spite of this heterogeneity a fairly great number of the authors who have treated *Ornithocercus magnificus* show neither by figures, references to figures, nor otherwise how they conceive this species. These investigators are as follows: — Chun (1886), Daday (1888), Hensen (1895, 1911), Ostenfeld (1898a), Lemmermann (1899a), Cleve (1900b, 1901a, 1901c, 1902b), Cleve, Ekman, and Pettersson (1901), Entz (1902a), Zacharias (1906), Karsten (1906, 1907), Schröder (1906a, 1911), Gräf (1909), Meunier (1910), Okamura (1912), Schiller (1912, 1912a, 1914), Issel (1921), and Lindemann (1924, p. 7). All these references should therefore rightly be furnished with question marks to indicate the uncertainty of their allocation. Lemmermann (1904, p. 643) points out that *Histioneis magnificus* Lemmermann (1899a, p. 317, 323, 327) refers to *Ornithocercus steini* [= *thurni*] only. Cleve (1897a), Pavillard (1905, 1916), and Faria and Cunha (1917) refer to all of Stein's (1883) figures and are thus marked with *partim* in our bibliographical list. Okamura (1907), who also refers to all of Stein's (1883) figures, represents as *O. magnificus* two specimens of *O. thurni;* whether or not he

found any *O. magnificus s. str.* cannot be decided from his published data. Stüwe (1909), who has a very broad concept of this species, including *O. magnificus s. str.*, *O. thurni*, *O. steini s. str.*, and *O. quadratus*, distinguishes his records of *O. magnificus s. str.* under the designation *O. magnificus* var. *a*. Entz (1902b, 1905) distinguishes two "varieties" of *O. magnificus*, viz., var. *steini* [= *thurni*] and var. *quadrata*, but it cannot be established from his data whether he found *O. magnificus s. str.* The specimen figured by Murray and Whitting (1899) under the name of *Histioneis magnifica* (Stein) belongs to *Ornithocercus thurni*, but the distributional data of these investigators probably refer to *O. magnificus s. str.* as well; the species was found to vary "greatly in size and in the character of the markings on the sail and funnel"; with regard to the use of Histioneis for Ornithocercus, see below. Bütschli (1885), Chun (1903), Zacharias (1906a, 1907, 1911), Willey and Hickson (1909), and Francé (1923) reproduce under the name of *O. magnificus* either of Stein's (1883) figures 4 and 5, Plate 23 [= *O. thurni*]. In recording *O. magnificus*, Whitelegge (1891) refers only to Bütschli's (1885) reproduction of Stein's (1883) Plate 23, figure 4 [= *O. thurni*]. Hjort (1911) reproduces Murray and Whitting's (1899, pl. 32, fig. 2) figure of *Histioneis magnifica* [= *Ornithocercus thurni*] under the name of *O. magnificus*. *Histioneis* (= *Ornithocercus*) *magnifica* Schröder (1900a) is a synonym of *Ornithocercus quadratus;* and the last name is considered a synonym of *O. magnificus* by Cleve (1903b). *Ornithocercus magnificus* Lindemann (1924, p. 5) refers to *Histioneis magnifica* Schröder (1900a). *O. magnificus* Fricke (1902) refers to *O. thurni*. Although Forti (1922) reproduced only Stein's (1883) Plate 23, figure 1 and 2, in other words only figures of *O. magnificus s. str.*, he evidently held a very broad concept of this species, since he was inclined to believe that *O. magnificus s. str.*, *O. steini* [= *thurni*], and *O. quadratus* were but stages in the life cycle of a single species; his material included possibly more than *O. magnificus s. str.*

Ornithocercus magnificus s. str. was established, as mentioned previously, by Schütt (1900a); the three specimens figured by Schütt (1900a) all belong to this species as conceived in the present paper. Two of the specimens previously figured by Schütt (1895, pl. 5, fig. 21: 1, 4) as *O. magnificus* are typical representatives of *O. magnificus s. str.;* a third specimen (1895, pl. 5, fig. 21: 2) is aberrant but may also be referable to this species. Two of these figures, figures 21: 1 and 21: 2, were later reproduced by Schütt (1896, 1899) in a somewhat modified form. Schmidt (1901), Ostenfeld and Schmidt (1901), Lohmann (1902, 1908a, 1920), Kofoid (1907a, 1911), and Ostenfeld (1915) have the same concept of this species as Schütt (1900a). The same is true with regard to Effenberger (1911) and Gran

(1912b), who reproduce Schütt's (1895) Plate 5, fig. 21: 1; to Jörgensen (1923), who gives an original figure of this species; and to Doflein (1909, 1911, 1916) and Oltmanns (1922) who reproduce under the name of *O. magnificus* not only Schütt's (1895) Plate 5, figure 21: 1, but also, evidently through an editorial error, one of Schütt's (1893, fig. 82) figures of *O. splendidus*.

Jörgensen (1923) mentions that in his manuscript he used the name *Ornithocercus minor* for *O. magnificus s. str.*

The following investigators use Histioneis as the generic name of this species: — Murray and Whitting (1899), Lemmermann (1899a, 1901a, 1905), Schröder (1900a), Cleve (1901c, 1902b, 1903b), Cleve, Ekman, and Pettersson (1901), Entz (1902b, 1905), Pavillard (1905, 1916), Meunier (1910), Issel (1921), and Forti (1922). With regard to this usage, see our treatment of the family Ornithocercidae, the section on the subdivisions (p. 494).

Occurrence: — *Ornithocercus magnificus* is recorded at seventy-six of the 127 stations. There are 20, 13, 6, 12, 17, and 8 stations on the six lines of the Expedition. Of these seventy-six stations, one (4583) is in the California Current; thirteen (4587, 4588, 4590, 4592, 4594, 4596, 4598, 4600, 4604, 4605, 4607, 4545, 4546) are in the Mexican Current; sixteen (4609, 4611, 4613, 4615, 4617, 4619, 4624, 4627, 4631, 4634, 4635, 4637, 4638, 4639, 4640, 4644) are in the Panamic Area; five (4646, 4647, 4648, 4650, 4671) are in the Peruvian Current; nine (4689, 4691, 4692, 4695, 4696, 4697, 4698, 4699, 4700) are in the Easter Island Eddy; two (4613, 4616) are in the Galapagos Eddy; twenty-six (4685, 4686, 4687, 4701, 4702, 4705, 4712, 4720, 4721, 4722, 4724, 4725, 4727, 4728, 4729, 4730, 4731, 4732, 4733, 4734, 4735, 4736, 4737, 4739, 4740, 4741) are in the South Equatorial Drift; one (4742) is in the South Equatorial Current; one (4542) is in the Equatorial Counter Current; two (4543, 4544) are in the North Equatorial Current. There are forty-two records from the surface (Stations 4583, 4588, 4590, 4592, 4596, 4600, 4604, 4607, 4611, 4615, 4617, 4619, 4624, 4627, 4631, 4635, 4638, 4639, 4640, 4644, 4686, 4692, 4696, 4698, 4700, 4702, 4712, 4716, 4720, 4725, 4727, 4729, 4731, 4733, 4735, 4740 [Salpa], 4741, 4542, 4543, 4544 [Salpa], 4545, 4546). At thirty-seven of these forty-two stations the species was taken in surface waters only; at five stations (4583, 4590, 4617, 4638, 4740), in hauls from 300–0 fathoms as well as at the surface; at Stations 4588 and 4619, in Salpa stomachs as well as in surface hauls. At one station (4737) it is recorded from 100–0 fathoms and 300–0 fathoms; at four stations (4689, 4728, 4732, 4736) from 800–0 fathoms and 300–0 fathoms; at two stations (4647, 4721) from 800–0 fathoms only. All the remaining records refer to hauls from 300–0 fathoms only.

The species was taken also in surface waters in Acapulco Harbor, adjacent to the Mexican Current. This station is not included in the 127 stations mentioned above.

The temperature range of these seventy-six stations at the surface was 66°–85°; the average was 77.5°. At the forty-two stations in the surface catches of which this species was found, the surface temperature ranged from 71° to 84°; the average was 78.5°. At Acapulco it was 83°.

For the surface catches the following frequencies are recorded: — 21% at one station (4546); 13% at one station (4604); 9% at two stations (4635, 4696);

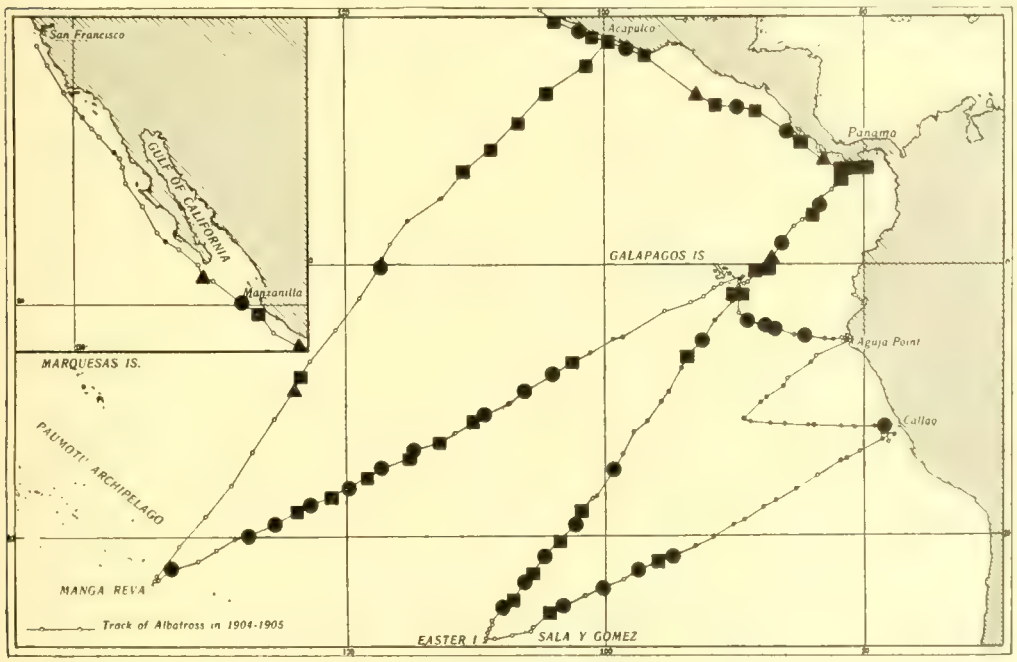

FIGURE 80.— Occurrence of *Ornithocercus magnificus* Stein, *s. str.* Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

7% at one station (4590); 6% at one station (4619); 5% at four stations (4596, 4600, 4692, 4545); 4% at one station (4607); 3% at three stations (4588, 4733, 4542); 2% at eleven stations (4592, 4615, 4617, 4624, 4627, 4631, 4638, 4639, 4720, 4731, 4543); 1% at seven stations (4640, 4644, 4702, 4712, 4716, 4725, 4735); in the remaining cases the frequency is less than 1%. For the catches from 100, 300, or 800 fathoms to the surface the records of frequency are as follows: 9% at two stations (4695, 4699); 8% at one station (4609); 7% at one station (4634); 6% at two stations (4637, 4689); 5% at four stations (4613, 4617,

4691, 4736); 4% at three stations (4590, 4638, 4697); 3% at four stations (4598, 4732, 4734, 4737); 2% at eight stations (4583, 4605, 4646, 4650, 4687, 4728, 4739, 4740); 1% at three stations (4648, 4685, 4701); at the remaining stations the frequency is less than 1%. For the catch made in Acapulco Harbor a frequency of less than 1% is recorded.

The species was first recorded by Stein (1883) "aus dem Atlantischen Meer." Later investigators have shown it to be widely distributed. The following authors have found it in the Atlantic between lat. 45° N. and lat. 42° S.: — Hensen (1895, 1911), Cleve (1897a, 1901c, 1902b, 1903b), Ostenfeld (1898a), Murray and Whitting (1899), Lemmermann (1899a), Karsten (1906), Zacharias (1906), Lohmann (1908), Gräf (1909), Stüwe (1909), Faria and Cunha (1917), and Jörgensen (1923). In the Caribbean Sea it was found by Murray and Whitting (1899) and Cleve (1901c). Of these authors Hensen (1911), Cleve (1901c), Murray and Whitting (1899), and Karsten (1906) found it at a great number of localities. Jörgensen (1923) recorded this species from a great number of stations throughout the Mediterranean. Other investigators who have found it in the Mediterranean are as follows: — Cleve (1903b) at lat. 37° N., long. 4° E., and lat. 33° N., long. 30° E.; Pavillard (1905, 1916) in the Gulf of Lyons; Forti (1922) in the Ligurian Sea; Daday (1888) and Zacharias (1906) in the Gulf of Naples; Entz (1902b, 1905), Zacharias (1906), Schröder (1906a, 1911), Schiller (1912, 1912a, 1914), and Issel (1921), in the Adriatic Sea; Schröder (1906a) in the Ionian Sea. In the Red Sea it has been found by Cleve (1900b, 1903b), Ostenfeld and Schmidt (1901), and Schröder (1906a); in the Gulf of Aden, by Ostenfeld and Schmidt (1901) and Schröder (1906a); in the Arabian Sea, by Cleve (1901a, 1903b), Ostenfeld and Schmidt (1901), and Schröder (1906a); in the Indian Ocean, by Cleve (1901a), Schröder (1906a), Karsten (1907), and Gräf (1909); in the Malay Archipelago, by Cleve (1901a) and Ostenfeld (1915); in the Gulf of Siam, by Schmidt (1901); in the South China Sea, by Schröder (1906a); in Japanese waters, by Okamura (1907, 1912); in the Pacific, at lat. 6° N., long. 111° W., by Lemmermann (1899a); at San Diego, California, by Kofoid (1911); in the Peruvian Current, at lat. 33° S., long. 82° W., and at lat. 23° S., long. 74° W., respectively, by Lemmermann (1899a) and by Zacharias (1906). Of the writers mentioned in the last sentence, Karsten (1907) found it at a great number of localities.

Most of the records referred to in the last paragraph were from surface hauls. The only records of closing-net hauls published as yet are the following by Karsten (1906, 1907): — Station 27, lat. 29° 20′ N., long. 15° 57′ W., 2500–2200

m., no statement as to condition of specimens; Station 65, lat. 1° 56′ S., long. 7° 48′ E., 300–200 m., living; Station 170, lat. 32° 53′ S., long. 83° 1′ E., 200–100 m., living; Station 181, lat. 12° 6′ S., long. 96° 44′ E., 500–300 m., dead, 200–100 m., dead; Station 182, lat. 10° 8′ S., long. 97° 14′ E., 200–100 m., dead; Station 191, west coast of Sumatra, 200–180 m., dead, 100–60 m., dead; Station 218, lat. 2° 29′ N., long. 76° 47′ E., 100–80 m., living; Station 221, lat. 4° 5′ S., long. 73° 24′ E., 200–160 m., living, 160–120 m., dead; Station 227, lat. 2° 56′ S., long. 67° 59′ E., 600–400 m., cells with protoplasmic contents; Station 228, lat. 2° 38′ S., long. 65° 59′ E., 300–200 m., living, 200–100 m., living; Station 229, lat. 2° 38′ S., long. 63° 37′ E., 1000–800 m., dead, 200–20 m., condition unknown; Station 236, lat. 4° 38′ S., long. 51° 16′ E., 180–130 m., dead, 100–80 m., living; Station 239, lat. 5° 42′ S., long. 43° 36′ E., 103–85 m., living, 120–105 m., dead; 80–65 m., living; 60–45 m., living; 40–25 m. and 20–15 m., condition unknown; Station 268, lat. 9° 6′ N., long. 53° 41′ E., 105–88 m., dead; 63–46 m., living; 42–25 m., living; 42–15 m., living.

According to the authors mentioned in the next to the last paragraph, this species occurs in waters of the following temperatures and salinities.

	Temperature Range	Number and Mean of Observations		Salinity Range	Number and Mean of Observations	
Murray and Whitting (1899)	57.0°–86.0°	125	75.5°			
Cleve (1901a)	77.4°–88.2°	5	80.9°	32.12–36.20	5	34.72
	78.1°–82.9°	5	77.9° *	33.06–33.80	5	33.59
Cleve (1901c)	62.6°–82.4°	150	73.0°	33.20–37.63	120	36.12
Cleve (1902b)		45	73.8°		45	36.11
Cleve (1903b)	60.2°–87.3°	20	76.5°	35.52–39.92	20	36.90
Ostenfeld and Schmidt (1901)	79.0°–84.5°					
Stüwe (1909)	68.5°–80.2°					
Issel (1921) (minimum)	54°					

* Lower than minimum temp.

Usually this species is fairly rare, or it occurs in moderate numbers. However, Schiller (1914, p. 14) records a sudden mass appearance ("gewaltige Mengen") in the Gulf of Trieste during September, 1909. The phenomenon lasted four days and affected the entire gulf.

Cleve, Ekman, and Pettersson (1901) give a chart of the distribution of this species in the Atlantic.

Of the investigators who have contributed to our knowledge of the distribution of this species, Schmidt (1901), Ostenfeld and Schmidt (1901), Lohmann (1908), Kofoid (1911), Ostenfeld (1915), and Jörgensen (1923) show by figures, references to figures, or otherwise that they conceive this species in the restricted sense established by Schütt (1900a). Cleve (1897a), Murray and Whitting (1899),

Pavillard (1905, 1916), Okamura (1907), and Faria and Cunha (1917), on the other hand, show that they have the same broad conception as Stein (1883), and their data of distribution thus may refer either to any or to all of the three species *Ornithocercus magnificus s. str.*, *O. thurni*, and *O. steini s. str.* Cleve (1903b) includes *O. quadratus* in *O. magnificus*, and his data therefore should be accepted with reservation. Stüwe (1909), who also has a very broad concept of the last species, distinguishes *O. magnificus s. str.* as *O. magnificus* var. *a*, and only his records of this "variety" have been included in the account given above. Forti's (1922) records may partly refer to *O. thurni* and *O. quadratus*. The remaining authors do not give any information by means of which their concept of *O. magnificus* may be judged, and so their distributional data should be accepted with reservation.

Ornithocercus magnificus is eupelagic and widely distributed in tropical, subtropical, and warm-temperate waters. It appears to be one of the most common representatives of this genus and occasionally may occur in enormous quantities causing the discoloration of the water. In the Eastern Pacific it occurs in the whole area investigated by the Expedition, but it is strikingly rare in the Peruvian Current. It is not recorded from the northern portion of the California Current, but it occurs occasionally as far to the north as at San Diego, California. Like most of the remaining species of this genus, it is relatively frequent in surface waters; and the highest records of frequency are from surface catches.

Ornithocercus thurni (Schmidt)

Plate 18, fig. 4–6. Figure 81, 82

? *Dinophysis galea* Pouchet, 1883, *partim*, p. 426, fig. G: 4.
Ornithocercus magnificus Stein, 1883, *partim*, pl. 23, fig. 4, 5. Bütschli, 1885, pl. 55, fig. 7. Whitelegge, 1891, p. 185. Cleve, 1897a, *partim*, p. 26, tab. 1. Chun, 1903, p. 75, fig. b. Zacharias, 1906a, p. 274, fig. 7; 1907, fig. 14; 1911, fig. 51. Okamura, 1907, *partim* (?), p. 132, pl. 4, fig. 27. Willey & Hickson, 1909, p. 184, fig. 8. Hjort, 1911, p. 367, fig. 4. Faria & Cunha, 1917, *partim*, p. 79. Francé, 1923, fig. 11: 2.
Parelion thurnii Schmidt, 1888, pl. 144, fig. 59–61; 1890, p. 22.
Histioneis magnifica Murray & Whitting, 1899, *partim*, p. 332, 333, tab. 1–9, pl. 32, fig. 2. Lemmermann, 1899a, p. 317, 323, 327. Pavillard, 1905, *partim*, p. 60, 81, 102; 1916, *partim*, p. 61.
Ornithocercus steinii Schütt, 1900a, *partim*, p. 5, 16, 17, fig. 7. Gran, 1912a, p. 935, fig. 7b; 1912b, p. 328, 329, fig. 234b. Ostenfeld, 1915, p. 7.
Histioneis steinii Lemmermann, 1901a, *partim*, p. 377; 1904, p. 317, 323, 327; 1905a, p. 37.
Ornithocerus magnificus Fricke, 1902, p. 55.
Histioneis magnificus var. *steinii* Entz, 1902b, p. 94; 1905, p. 112 (as *magnifica* var. *steinii*).
Ornithocercus steini Kofoid, 1907a, p. 206. Jörgensen, 1923, p. 36, 37, 38, fig. 49.
Ornithocercus magnificus var. *c* and *d* Stüwe, 1909, p. 235, 254, 275, 288.
Histioneis magnifica var. *steinii* Forti, 1922, p. 114.

Diagnosis: — Lateral outline subcircular. Cingular lists: anterior 0.46–0.80, posterior 0.47–0.74 the greatest depth of body; anterior with five to nine com-

plete ribs, often branched distally, and numerous short, marginal ribs; posterior with 11–16 complete and often simple ribs. Left sulcal list ends on dorsal side of body 0.10–0.40 the greatest depth of body from posterior cingular list; with three narrowly to fairly broadly rounded lobes, one of which is posteroventral, one antapical, and one posterodorsal; width at posteroventral lobe 0.65–1.16, at antapical lobe 0.54–1.10, and at posterodorsal lobe 0.51–1.02 the greatest depth of body; typically with five ribs behind fission rib and with submarginal rib connecting these ribs; with reticulum in each lobe; *a*-rib extends into posterodorsal lobe; *b*-rib ends ventrally to this lobe, and *c*- and *e*-ribs at vertices of antapical and posteroventral lobes. Length of body, 43.7–81.5 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — This is a fairly large or medium-sized species, with subcircular outline in lateral view, deepest in or near the middle. The ratio between the length and the depth of the body is 0.87–1.05: 1; in our specimens this ratio is 0.98 (0.91–1.05): 1. The longitudinal axis is deflected posterodorsally at 10° (5°–15°).

The epitheca is 0.53 (0.42–0.67) as deep as the hypotheca, slightly convex or almost flat, highest in the center or dorsally, and tilted ventroposteriorly at 5°–15°. The transverse furrow often is rather strikingly concave, but may be almost flat (Figure 81: 7); its dorsal width is 0.42 (0.37–0.55) the greatest depth of the body; its ventral width is 0.48 (0.32–0.62) its dorsal width. The posterior cingular list is 0.35 (0.28–0.48) the length of the body from the apex. The dorsal, posterior, and ventral margins of the hypotheca are well rounded and confluent; or any one of them may be slightly flattened (Figure 81: 3).

The anterior cingular list is 0.46–0.80 the greatest depth of the body and has an anterior inclination of 40° (35°–50°); in our specimens its width is 0.62 (0.46–0.75). It has on each valve five to nine complete radial ribs which, when fully developed, usually are furnished distally with candelabra-like branches (Stein, 1883, pl. 23, fig. 4, 5); between these main ribs there are numerous short, marginal radial ribs, which sometimes are connected by anastomoses. The posterior cingular list is 0.60 (0.47–0.74) the greatest depth of the body and is inclined anteriorly at 65° (50°–80°); it has on each valve 11–16 complete, subequidistant ribs, which usually are simple but some of which may be branched proximally; between the main ribs a few short ribs may be found (Okamura, 1907, pl. 4, fig. 27a). The right sulcal list is comparatively large, of subuniform width throughout the greater portion of its length and rounded posteriorly; sometimes it ends at the *e*-rib of the left sulcal list, sometimes it extends to the *d*-rib; its average width

is 0.17–0.23 the greatest depth of the body; at least in some specimens it has a few ribs (Figure 81: 6). The left sulcal list ends on the dorsal side of the body at a distance from the posterior cingular list equaling 0.25 (0.10–0.40) the greatest depth of the body and is characterized by three narrowly to fairly broadly rounded posterior lobes, one of which is posteroventral, one antapical, and one posterodorsal. In our specimens the width of this list at the anterior main rib is 0.50 (0.41–0.66), at the fission rib 0.55 (0.46–0.72), at the posteroventral lobe 0.81 (0.65–1.16), at the antapical lobe 0.75 (0.54–0.91), and at the posterodorsal lobe 0.67 (0.51–0.96) the greatest depth of the body. In one of the specimens figured by Stein (1883, pl. 23, fig. 4), which has this list somewhat wider than any other figured specimen, the corresponding values are 0.67, 0.73, 1.03, 1.10, and 1.02. The ventral margin of this list sometimes (Figure 81: 1) is almost straight, sometimes it is gently convex (Figure 81: 2) or sigmoid (Figure 81: 11), or it may form a broadly rounded lobe near the fission rib (Figure 81: 3–7). Between the tip of the antapical lobe and the tips of the posteroventral and posterodorsal lobes, the posterior margin usually (Figure 81: 1, 2) is gently concave, but it may be almost straight (Jörgensen, 1923, fig. 49), strikingly and evenly concave (Figure 81: 6), or it may have a small (Figure 81: 4) or a large (Figure 81: 11) lobe between the antapical and posteroventral lobes. The dorsal margin of this list is gently convex or nearly straight. Between the anterior main rib and the fission rib this list may have one or a few usually irregular ribs (Figure 81: 2, 4, 5). Behind the fission rib it typically (Figure 81: 1) has five radial ribs connected distally by a submarginal rib. The submarginal rib extends along the entire posterior margin of the list and may in some specimens be traced up to the fission rib (Figure 81: 5, 6); in each of the three posterior lobes it usually forms a more or less developed reticulum; sometimes (Figure 81: 3) it is incomplete, sometimes (Figure 81: 4) it is marginal, and in young specimens (Figure 81: 7–10) it is entirely absent. Of the five radial ribs behind the fission rib, the *a*-rib (*i.e.*, the dorsal rib) extends into the posterodorsal lobe; the *b*-rib ends about midway between the posterodorsal and antapical lobes; the *c*-rib ends at the vertex of the antapical lobe; the *d*-rib, about midway between the antapical and posteroventral lobes; and the *e*-rib at the vertex of the posteroventral lobe. In our specimens the lengths of these five ribs, measured in straight lines to the points where these ribs join the submarginal rib, are as follows: — the *a*-rib is 0.57 (0.48–0.66), the *b*-rib 0.44 (0.35–0.51), the *c*-rib 0.65 (0.44–0.78), the *d*-rib 0.53 (0.45–0.67), and the *e*-rib 0.70 (0.57–1.00) the greatest depth of the body. Sometimes (Figure 81: 3, 4) two *d*-ribs are present, sometimes less than five ribs are developed. In the

latter case the differences presumably are due to age; the *a*- and *e*-ribs appear to develop before the remaining ribs; the next to appear is the *c*-rib, then comes the *b*-rib, and finally the *d*-rib. In young specimens these ribs are simple, but soon they develop short branches, which probably increase in number with age. Dorsally to the *a*-rib as well as at the distal end of the anterior fission rib, reticulation sometimes is to be found.

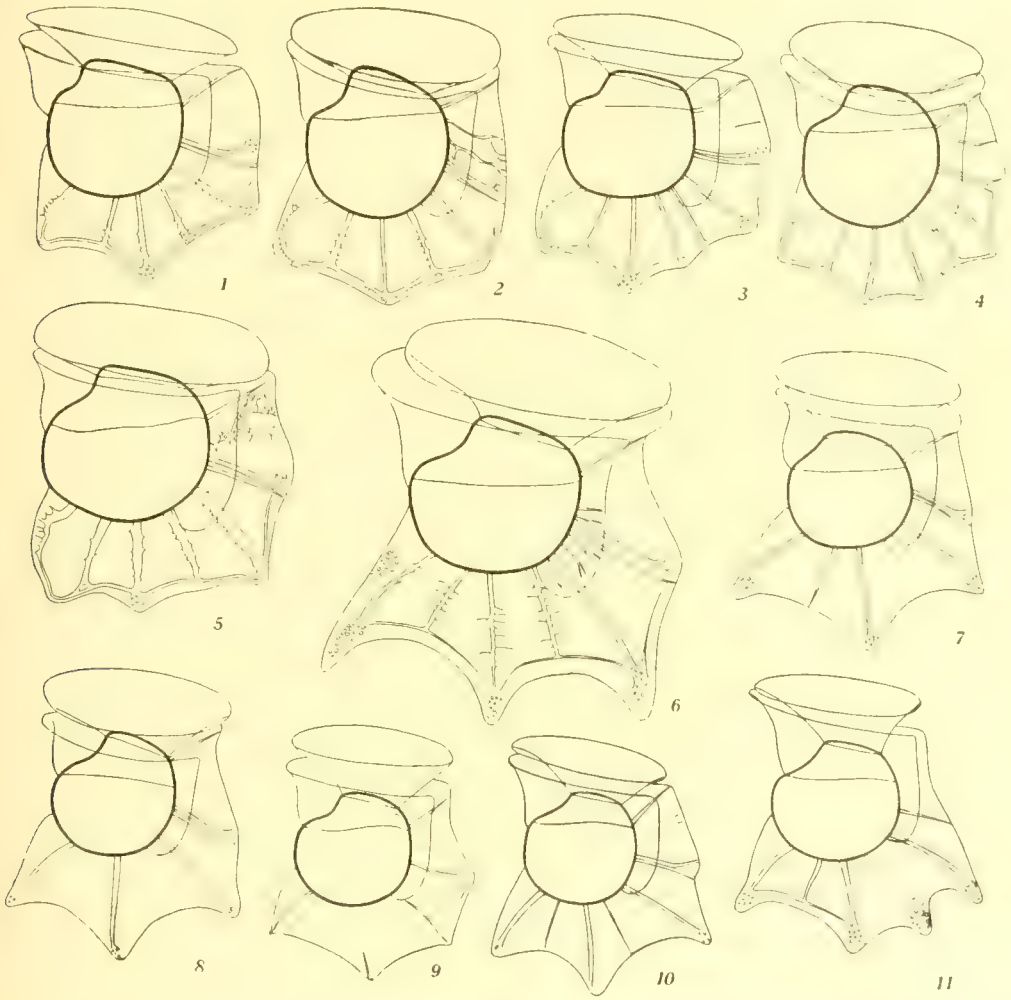

FIGURE 81.— *Ornithocercus thurni* (Schmidt), right lateral view, illustrating variations in size of body, and in shape and structure of left sulcal list. × 340. 1, 3, from Station 4607 (surface); 2, from Station 4613 (300–0 fathoms); 4, from Station 4617 (300–0 fathoms); from 5, Station 4638 (300–0 fathoms); 6, from Station 4737 (150–0 fathoms); 7, 8, 9, 11, from Station 4697 (300–0 fathoms); 10, from Station 4691 (300–0 fathoms).

The whole thecal wall is porulate, that of the hypotheca is areolate. The areoles are of moderate and subuniform size (Jörgensen, 1923, fig. 49), and each of them has a pore in the middle. Near the middle of the body there are about

ten to twenty areoles across the face of each valve. Phaeosomes, sometimes in very large numbers, are to be found in the transverse furrow.

The proportions of twenty of our specimens and of the specimens figured by Stein (1883, pl. 23, fig. 4, 5), Murray and Whitting (1899, pl. 32, fig. 2), Schütt (1900a, fig. 7), Okamura (1907, pl. 4, fig. 27), and Jörgensen (1923, fig. 49) were measured.

Dimensions: — Our specimens: Length of body, 43.7–61.4 μ (average, 51.4 μ). Greatest depth of body, 44.4–66.6 μ (average, 52.4 μ). We do not know the size of the type specimen (Schmidt, 1883, pl. 144, fig. 61), nor that of the two specimens figured by Stein (1883, pl. 23, fig. 4, 5). According to Stein's (1883) information about the magnifications of his figures given in an introductory remark to the explanations of the plates, these specimens were somewhere between 62.4 and 97.8 μ long. The specimen represented by Murray and Whitting's (1899) Plate 32, figure 2, was 58.8 μ long and 68.0 μ deep; the one figured by Schütt (1900a, fig. 7) was 81.5 μ long and about as deep as long; Okamura's (1907, pl. 4, fig. 27b) specimen was about 54.5 μ long and 47.8 μ deep; Jörgensen's (1923, fig. 49), 63.5 μ long and 65.0 μ deep.

Variations: — The shape of the body, and the shape of the cingular lists and of the right sulcal list are rather constant. The size of the body and the shape and structure of the left sulcal list, on the other hand, are strikingly variable. The length of the body varies from 43.7 μ to 81.5 μ. The variations in size should be correlated with the peculiar mode of reproduction illustrated by Plate **18**, figure 2, 7, 9. In the case of the left sulcal list the most variable features are the number and the shape of the ribs and the shape of the margin between the *a*- and *c*-ribs and between the *c*- and *e*-ribs. The normal number of ribs in the portion of this list that belongs to the right valve is six, viz., the *a*-, *b*-, *c*-, *d*-, and *e*-ribs, and the fission rib. Sometimes seven ribs are found, in which case two *d*-ribs are developed (Figure 81: 3, 4); sometimes the number is more or less reduced. In the latter case, the *d*-rib usually is the first to be absent (Figure 81: 7); next in order comes the *b*-rib (Figure 81: 8), then the *c*-rib (Figure 81: 9). The submarginal rib is well developed in most specimens but may be partly (Figure 81: 3, 11) or entirely (Figure 81: 7, 8, 9, 10) absent. Sometimes the ribs are simple but usually at least some of them are furnished with short branches. Any of the *a*-, *b*-, *c*-, *d*-, and *e*-ribs may be branched proximally (as in Figure 83: 8, of *Ornithocercus steini*). The lobes of this list at the tips of the *a*-, *c*-, and *e*-ribs generally are more or less reticulated, and reticulation also may be found dorsally to the *a*-rib, but sometimes these structures are lacking (Figure 81: 9). The variations

in the number and shape of the ribs and in the reticulation seem largely to be due to age; the older a specimen is the more complex is its structure. As to the shape of the margin of this list between the *a*- and *c*-ribs and between the *c*- and *e*-ribs, the following variations have been observed: — sometimes the margin between these ribs is almost straight (Jörgensen, 1923, fig. 49); sometimes it is gently concave (Figure 81: 2), sometimes strikingly but evenly concave (Figure 81: 6); sometimes a small (Figure 81: 4) or a large (Figure 81: 11) lobe is formed between the *c*- and the *e*-ribs. It should finally be pointed out that the various forms of this species figured and described in the present paper are connected by a fairly complete series of intermediate forms. The eleven specimens of Figure 81 illustrate the range of variation exhibited by this species in the material of the Expedition. Most of our specimens (111, *i.e.*, 50.9% out of the 218 that were carefully examined) agreed with the specimen represented by Figure 81: 1; fifty-three specimens (24.3%) agreed with Figure 81: 7; thirteen specimens (6.0%) with Figure 81: 8; twelve (5.5%) with Figure 81: 7, but they lacked the *d*-rib and had but a slight indication of the *b*-rib; eleven (5.0%) with Figure 81: 10, but they had the *b*- and *d*-ribs less distinctly developed; three (1.4%) with Figure 81: 2; three (1.4%) with Figure 81: 10; three (1.4%) with Figure 81: 7, but they lacked the *d*-rib; two (0.9%) with Figure 81: 3, but they lacked the submarginal rib; two (0.9%) with Figure 81: 11; and of each of the forms represented by Figure 81: 3, 4, 5, 6, 9, only one specimen was found.

Comparisons: — The type specimen as figured by Schmidt (1888, pl. 144, fig. 59–61), as well as the specimens figured by Murray and Whitting (1899, pl. 32, fig. 2) and by Okamura (1907, pl. 4, fig. 27a, b), especially one of those figured by the last author (fig. 27a), show a striking resemblance to the majority of our specimens. On the other hand, none of our specimens agrees completely with the specimen represented by Stein's (1883) Plate 23, figure 4, but the differences exhibited by the latter specimen lie within the range of variation found in the material of the Expedition, with the exception of the size of the body and the relative size of the left sulcal list. The specimen figured by Schütt (1900a, fig. 7) resembles fairly closely the one represented by Stein (1883, pl. 23, fig. 4). Jörgensen's (1923, fig. 49) specimen approaches our Figure 81: 1, but it lacks the submarginal rib, a difference of no systematic consequence.

In spite of the striking variability characteristic of this species as conceived in the present paper, we are forced to assume that we are dealing with a single systematic unit by the following facts: — (*1*) the size varies very decidedly within the species of this genus, due to the peculiar mode of division illustrated by Plate

18; (*2*) the structure of the left sulcal list is subject to similar and about equally striking variations also within other species of this genus, *e.g.*, *Ornithocercus magnificus*, and these variations appear to be due to differences in age (Schütt, 1900a); (*3*) the various forms recorded are connected by fairly complete series of intermediate specimens.

No specimens have been found as yet which are distinctly intermediate between *Ornithocercus thurni* and any of the other known species of this genus. The specimen represented by Figure 81: 11, resembles *O. steini* in so far as the lobe between the *c*- and the *e*-ribs of the left sulcal list is concerned, but its *a*- and *b*-ribs are typical of *O. thurni*. The species is characterized especially by its left sulcal list, which is three-lobed and furnished with a submarginal rib and five radial ribs behind the fission rib; the *a*-rib extends into the dorsal lobe, the *b*-rib ends ventrally to the dorsal lobe, the *c*-rib at the vertex of the middle or antapical lobe, and the *e*-rib at the vertex of the ventral lobe. Its closest relatives probably are *O. magnificus* and *O. steini*. From the former species it differs strikingly in size and in the fact that the *c*- and *e*-ribs end at the vertices of the middle and ventral lobes, respectively. From *O. steini* it differs in having the *b*-rib end distinctly ventrally to the dorsal lobe and in the relative shortness of the *b*- and *d*-ribs when compared to the *c*-rib. From *O. carolinae*, which also has a three-lobed left sulcal list, it is easily recognized by the relatively smaller size of the middle lobe and by the smaller number of radial ribs in this list (see also *O. quadratus*).

Synonymy: — This species was first established by Schmidt (1888), who made it the type of a new genus of diatoms under the name of *Parelion thurnii*. Schütt (1896, p. 28) wrote Parelion as a synonym of Ornithocercus but did not mention the specific name *thurnii*. Fricke (1902) in his list of the species of Schmidt's Atlas der Diatomaceenkunde, substituted the name of *Ornithocercus magnificus* for *Parelion thurnii*. Other investigators have completely disregarded the last name. However, although this procedure is likely to bring about some confusion, we are forced to revive the specific name of *thurni*, since Schmidt figured his specimen so well that its specific allocation is beyond all doubt.

Later this species was established under the name of *Ornithocercus steinii* by Schütt (1900a), who subdivided Stein's (1883) *O. magnificus* into two species, *O. magnificus s. str.* and *O. steinii*. To the last species Schütt (1900a) refers only Stein's (1883) Plate 23, figure 4, but figure 5 of this plate also belongs to it. Of the three specimens figured by Schütt (1900a) as *O. steini*, only one, his figure 7, is referable to this species as conceived in the present paper. The two others, his figures 5 and 6, are, according to our opinion, fairly young and undifferentiated

representatives of a species later on described and figured in a late stage by Kofoid (1907a) as *O. serratus*. For this last species we retain the name *O. steini s. str.*

Under the name of *Ornithocercus magnificus* reproductions of either one or the other of Stein's (1883) figures 4 and 5, Plate 23 [= *O. thurni*] are given by Bütschli (1885), Chun (1903), Zacharias (1906a, 1907, 1911), Willey and Hickson (1909), and Francé (1923). Whitelegge (1891) refers under the same name only to Bütschli's (1885) reproduction of Stein's (1883) Plate 23, figure 4 [= *O. thurni*]. The specimen figured by Murray and Whitting (1899) as *Histioneis magnifica* (Stein) belongs to *Ornithocercus thurni*, but the distributional data of these investigators probably refer to *O. magnificus s. str.* as well; the species was found to be very variable (as to the use of Histioneis for Ornithocercus, see below). Reproductions of Murray and Whitting's (1899) figure of *Histioneis magnifica* [= *O. thurni*] were given by Hjort (1911) and by Gran (1912a, 1912b); Hjort (1911) used the name *O. magnificus*, while Gran (1912a, 1912b) used *O. steinii*. In recording *O. magnificus*, Okamura (1907) referred to all the five figures given by Stein (1883) under this name, but he represented only two specimens of *O. thurni*. Whether he found only the last species or *O. magnificus s. str.* as well, cannot be decided from his published data. Cleve (1897a), Pavillard (1905, 1916), and Faria and Cunha (1917) also refer to all of Stein's (1883) figures of *O. magnificus*, but do not give any figures. It should also be mentioned in this connection that *O. thurni* might be included in the records of the several authors who have reported *O. magnificus* without showing by figures, references to figures, or otherwise how they conceive this species (see *O. magnificus*, the section on synonymy, p. 534). Stüwe (1909), too, had a very broad concept of *O. magnificus*, including in this species *O. magnificus s. str.*, *O. thurni*, *O. steini s. str.*, and *O. quadratus*, but he distinguished *O. thurni* as *O. magnificus* var. *c* and var. *d*. Entz (1902b, 1905) recorded *Ornithocercus thurni* as *Histioneis magnificus* var. *steinii* and *H. magnifica* var. *steinii;* and Forti (1922) was inclined to regard this species and *Ornithocercus magnificus* as stages in the life cycle of a single species. Lemmermann (1904), who held the same concept of *Ornithocercus steini* [= *thurni*] as did Schütt (1900a), pointed out that *Histioneis magnifica* Lemmermann (1899a, p. 317, 323, 327) is a synonym of *Ornithocercus steini* [= *thurni*]. Kofoid (1907a), Ostenfeld (1915), and Jörgensen (1923) also have the same concept of *O. steini* [= *thurni*] as Schütt (1900a); Jörgensen (1923) figures this species. Goldschmidt (1907) and Wallengren and Hennig (1911) give a fanciful reproduction of Stein's (1883) Plate 23, figure 4 [= *O. thurni*], taken from Haeckel ("Kunstformen") that does not corre-

spond to any known species; no name was applied by these authors to this reproduction.

Pouchet (1883, fig. G: 1) figured under the name of *Dinophysis galea* a specimen that cannot certainly be referred to *Ornithocercus thurni*. His figure must be regarded as too sketchy for specific identification.

The following investigators use Histioneis as a generic name of this species:— Murray and Whitting (1899), Lemmermann (1899a, 1901a, 1904, 1905a), Entz (1902b, 1905), Pavillard (1905, 1916), and Forti (1922). With regard to this usage, see our treatment of the family Ornithocercidae, the section on the subdivisions (p. 494).

Occurrence: — *Ornithocercus thurni* is recorded at seventy-four of the 127 stations. There are 18, 10, 11, 12, 16, and 7 stations on the six lines of the Expedition. Of these seventy-four stations, one (4583) is in the California Current; eleven (4587, 4588, 4590, 4592, 4594, 4596, 4598, 4600, 4604, 4605, 4607) are in the Mexican Current; twelve (4609, 4613, 4615, 4617, 4619, 4623, 4631, 4634, 4637, 4638, 4640, 4644) are in the Panamic Area; four (4646, 4647, 4664, 4671) are in the Peruvian Current; eight (4689, 4691, 4692, 4695, 4696, 4697, 4699, 4700) are in the Easter Island Eddy; four (4713, 4714, 4715, 4716) are in the Galapagos Eddy; twenty-nine (4679, 4680, 4681, 4682, 4683, 4684, 4685, 4686, 4701, 4705, 4709, 4717, 4719, 4721, 4722, 4724, 4727, 4728, 4730, 4731, 4732, 4733, 4734, 4735, 4736, 4737, 4739, 4740, 4741) are in the South Equatorial Drift; three (4742, 4743, 4540) are in the South Equatorial Current; and two (4541, 4542) are in the Equatorial Counter Current. There are thirty-six records from the surface (Stations 4583, 4588 [Salpa], 4590, 4592, 4596, 4600, 4604, 4607, 4615, 4617, 4619, 4623, 4631, 4638, 4640, 4644, 4646, 4664 [Salpa], 4680, 4682, 4684, 4686, 4692, 4696, 4700, 4714, 4716, 4727, 4731, 4733, 4735, 4741, 4743, 4540, 4541, 4542). At thirty-one of these thirty-six stations the species was taken in surface waters only; at five stations (4583, 4590, 4617, 4638, 4646) in hauls from 300–0 fathoms as well as at the surface; at Stations 4619 and 4646 in Salpa stomachs as well as in surface hauls. At one station (4737) it is recorded from 100–0 fathoms and 300–0 fathoms; at one station (4713) from 150–0 fathoms and 300–0 fathoms; at four stations (4681, 4701, 4715, 4724) from 800–0 fathoms and 300–0 fathoms; at two stations (4647, 4728) from 800–0 fathoms only. All the remaining records refer to hauls from 300–0 fathoms only.

The species was taken also in surface waters in Acapulco Harbor, off the Mexican Current. This station is not included in the 127 stations mentioned above.

The temperature range of these seventy-four stations at the surface was 66°–85°; the average was 76.8°. At the thirty-six stations in the surface catches of which the species was found, the surface temperature ranged from 68° to 84°; the average was 77.4°. At Acapulco it was 83°.

For the surface catches the following frequencies are recorded: — 37% at one station (4619, Salpa); 23% at one station (4619); 10% at two stations (4607, 4615); 7% at one station (4604); 5% at two stations (4617, 4696); 2% at nine stations (4592, 4596, 4600, 4631, 4638, 4682, 4714, 4716, 4540); 1% at three stations (4590, 4640, 4733); in the remaining cases the frequency is less than 1%.

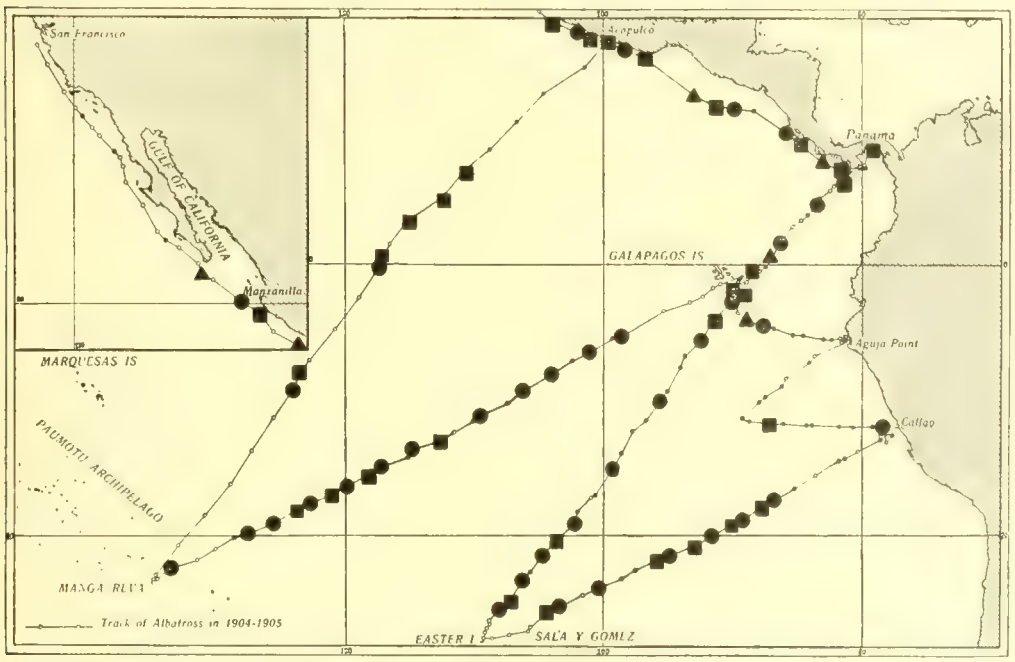

FIGURE 82.— Occurrence of *Ornithocercus thurni* (Schmidt). Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

For the catches from 100, 150, 300, or 800 fathoms to the surface the records of frequency are as follows: — 16% at one station (4613); 10% at one station (4713); 7% at one station (4715); 6% at one station (4638); 4% at five stations (4598, 4609, 4683, 4730, 4740); 2% at eight stations (4617, 4634, 4681, 4695, 4701, 4717, 4734, 4737); 1% at eleven stations (4647, 4679, 4689, 4691, 4699, 4705, 4728, 4732, 4736, 4739, 4742); at the remaining stations the frequency is less than 1%. For the catch made in Acapulco Harbor a frequency of less than 1% is recorded.

Schütt (1900a) does not give any information as to the type locality. The following investigators have found this species in the Atlantic between lat. 45° N.

and lat. 30° S: — Cleve (1897a), Murray and Whitting (1899), Stüwe (1909), Faria and Cunha (1917), and Jörgensen (1923). In the Caribbean Sea it was found by Murray and Whitting (1899). Jörgensen (1923) found it at a few stations in the eastern as well as in the western Mediterranean. Other investigators who have found it in the Mediterranean are as follows: — Pouchet (1883) and Pavillard (1905, 1916) in the Gulf of Lyons; and Entz (1902b, 1905) in the Adriatic Sea. Ostenfeld (1915) recorded it from the Malay archipelago; Whitelegge (1891) from Sydney, Australia; Stein (1883) "aus der Südsee"; Lemmermann (1899a) between the island of Laysan and Hawaii.

Most of the records referred to in the last paragraph were from surface hauls. No records of closing-net hauls have been published as yet. According to Murray and Whitting (1899), the species occurs in temperatures ranging from 57.0° to 86.0°; mean of 125 observations, 75.5°.

Of the investigators who have contributed to our knowledge of the distribution of this species, Stein (1883), Whitelegge (1891), Lemmermann (1899a), Entz (1902b, 1905), Stüwe (1909), Ostenfeld (1915), and Jörgensen (1923) show by figures, references to figures, or otherwise that their data refer to *Ornithocercus thurni* as conceived in the present paper. Cleve (1897a), Murray and Whitting (1899), Pavillard (1905, 1916), Okamura (1907), and Faria and Cunha (1917), on the other hand, show that they have the same broad conception of *O. magnificus* as Stein (1883), and their data of distribution thus may refer either to any or to all of the three species *O. magnificus*, *O. thurni*, and *O. steini s. str.* With regard to the data of distribution of Pouchet (1883), see the section on synonymy (p. 548); compare also the account of *O. magnificus* (p. 534).

Ornithocercus thurni is eupelagic and widely distributed in tropical, subtropical, and warm-temperate waters. While in tropical seas this species is about as common as *O. magnificus*, it is rare in warm-temperate and subtropical waters (*e.g.*, in the Mediterranean), when compared with that species. In the Eastern Pacific it occurs in the whole area investigated by the Expedition, but it is strikingly rare in the Peruvian Current and is not recorded from the northern portion of the California Current; however, it occurs occasionally as far to the north as at San Diego, California. Most of the record stations of high frequencies are in or near the Panamic Area, in the Galapagos Eddy, and in the Easter Island Eddy. This species is relatively frequent in surface waters; it should be observed that the highest records of frequency are from surface catches.

Ornithocercus steini Schütt, *s. str.*

Plate 16, fig. 1. Figure 83, 84

Ornithocercus magnificus Stein, 1883, *partim*, pl. 23, fig. 3.
Ornithocercus steini Schütt, 1900a, *partim*, fig. 5, 6.
Ornithocercus serratus Kofoid, 1907a, p. 206, pl. 15, fig. 93. Kofoid & Michener, 1911, p. 300. Faria & Cunha, 1917, p. 79. Jörgensen, 1923, p. 38, 43, 44, fig. 52.
Ornithocercus magnificus var. *b* Stüwe, 1909, p. 254, 275, 288.

Diagnosis: — Subcircular in lateral outline. Cingular lists: anterior, 0.49–0.73, posterior 0.45–0.72 the greatest depth of body; anterior with seven to nine complete ribs, sometimes branched distally, and with some short, marginal ribs; posterior with ten to nineteen complete and often simple ribs. Left sulcal list ends on dorsal side of body, at or near posterior cingular list; with four nearly equidistant, narrowly to fairly broadly rounded posterior lobes, viz., the posteroventral, midventral, middorsal, and posterodorsal lobes; width at posteroventral lobe 0.53–1.12, at midventral lobe 0.51–1.04, at middorsal lobe 0.50–1.00, at posterodorsal lobe 0.48–0.97 the greatest depth of body; typically with five ribs behind fission rib and with reticulum in each lobe; submarginal rib may be present; *a*-rib ends near middle of dorsal margin of list; each of the *b*- to *e*-ribs ends at the vertex of one of the four lobes. Length of body, 54.8–67.6 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — This is a fairly large species, subcircular in lateral view, deepest in or near the middle. The ratio between the length and the depth of the body is 0.92 (0.82–1.00) : 1. The longitudinal axis may be perpendicular to the posterior cingular list, but usually it is deflected posterodorsally at 7° (1°–15°).

The epitheca is 0.61 (0.54–0.67) as deep as the hypotheca, slightly convex or nearly flat, highest in or near the center or dorsally, and tilted ventroposteriorly at 5°–15°. The transverse furrow is moderately or but slightly concave; its dorsal width is 0.40 (0.34–0.53) the greatest depth of the body; its ventral width is 0.47 (0.31–0.62) its dorsal width. The posterior cingular list is 0.36 (0.29–0.46) the length of the body from the apex. The dorsal, posterior, and ventral margins of the hypotheca are well rounded and confluent; or any of them may be slightly flattened.

The anterior cingular list is 0.49–0.73 the greatest depth of the body and has an anterior inclination of 40° (30°–50°); in our specimens its width is 0.57 (0.49–0.67); it has on each valve seven to nine complete, radial ribs, which, when fully developed, may be furnished distally with candelabra-like branches (Kofoid, 1907a, pl. 15, fig. 93); between these main ribs there is a varying number of short,

marginal radial ribs, which sometimes are connected by anastomoses. The posterior cingular list is 0.56 (0.45–0.72) the greatest depth of the body and is inclined anteriorly at 65° (50°–85°); it has on each valve ten to nineteen complete, subequidistant ribs, some of which may be branched proximally. The right sulcal list is comparatively large, of subuniform width throughout the greater portion of its length and rounded posteriorly; it appears always to end near the *d*-rib of the left sulcal list; its average width is 0.16–0.20 the greatest depth of the body; at least in some specimens it has a few ribs (Figure 83: 5; Plate **16**, fig. 1). The left sulcal list ends on the dorsal side of the body, at or near the posterior cingular list; the maximum length of this distance is about 0.33 the greatest depth of the body. The list is characterized by four (in exceptional cases by five, Figure 83: 7) nearly equidistant, narrowly to fairly broadly rounded posterior lobes, which we designate, according to their positions, the posteroventral, the midventral, the middorsal, and the posterodorsal lobes. In most specimens these four lobes are well marked, but they may be but slightly indicated (Figure 83: 10) or almost absent (Figure 83: 11). In our specimens the width of this list at the anterior main rib is 0.48 (0.42–0.57), at the fission rib 0.54 (0.45–0.67), at the posteroventral lobe 0.69 (0.53–0.88), at the midventral lobe 0.67 (0.51–0.85), at the middorsal lobe 0.65 (0.50–0.83), and at the posterodorsal lobe 0.62 (0.48–0.79) the greatest depth of the body. In the specimen figured by Jörgensen (1923, fig. 52), which has this list somewhat wider than in any other figured specimen, the corresponding values are: 0.55, 0.81, 1.12, 1.04, 1.00, and 0.97. The ventral margin of this list usually forms a fairly distinct lobe at the fission rib (Figure 83: 2), but it may be almost straight, gently convex (Figure 83: 10, 11), or somewhat irregular (Figure 83: 5). The dorsal margin is gently convex in most specimens, but it may be somewhat angular at the end of the *a*-rib (Figure 83: 10, 12). Between the anterior main rib and the fission rib this list often has one to three ribs or an irregular reticulum (Figure 83: 11). Behind the fission rib it typically (Figure 83: 2) has five complete radial ribs, the distal ends of which may or may not be connected by a very weak submarginal rib, reticulations in the four lobes as well as dorsally to the *a*-rib and at the distal end of the fission rib, and in some cases it may have a few short, irregular ribs between the bases of the main ribs (Figure 83: 1; Kofoid, 1907a, pl. 15, fig. 93). Of the five main radial ribs behind the fission rib, the *a*-rib (*i.e.*, the dorsal rib) ends near the middle of the dorsal margin of this list, the *b*-rib ends at the vertex of the posterodorsal lobe, the *c*-rib at the vertex of the middorsal lobe, the *d*-rib at the vertex of the midventral lobe, and the *e*-rib at the vertex of the posteroventral lobe. In our specimens the lengths of these ribs are

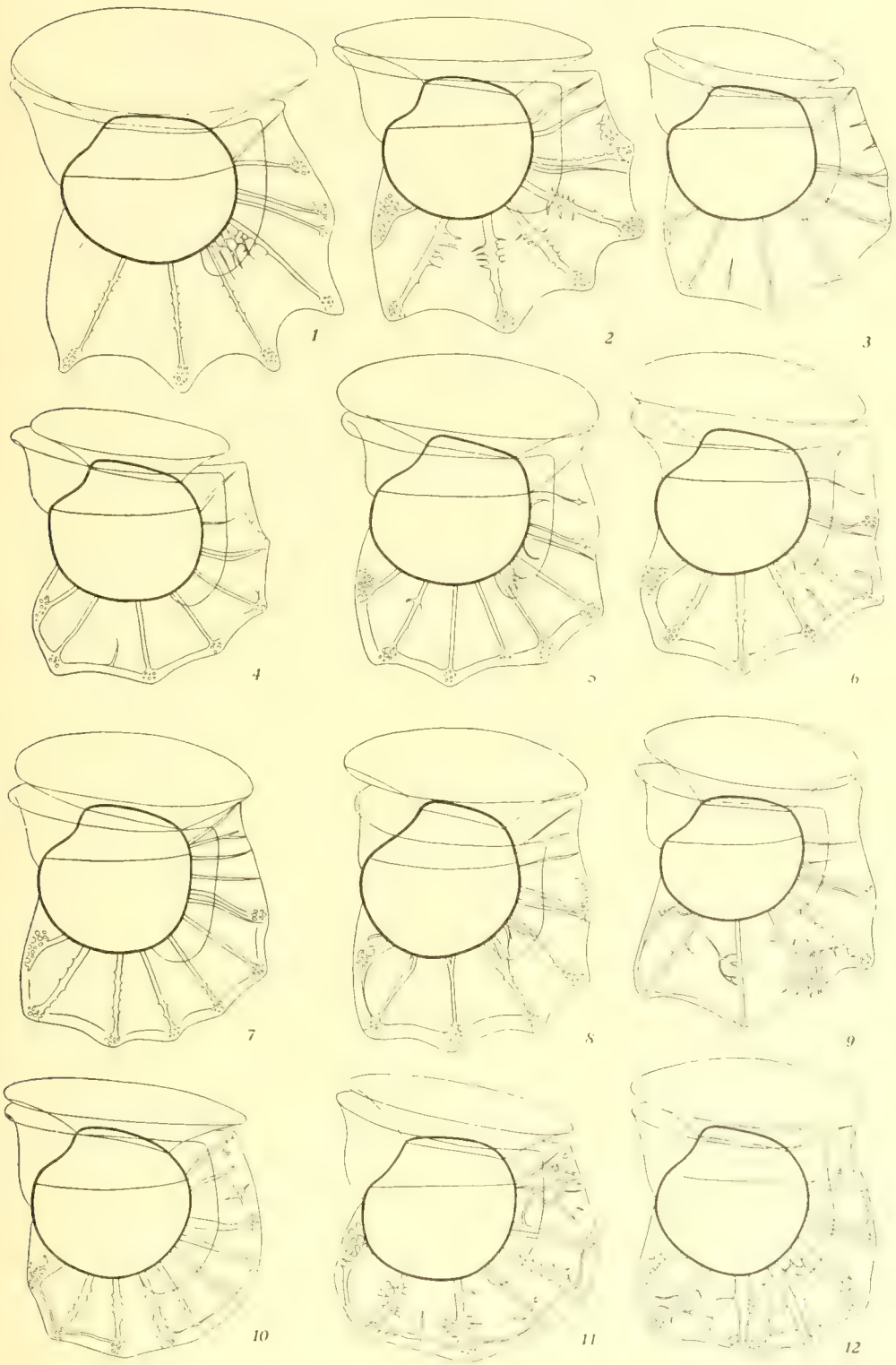

FIGURE 83.— *Ornithocercus steini* Schütt, *s. str.*, right lateral view, illustrating variations in shape and structure of left sulcal list. × 340. 1, from Station 4742 (300–0 fathoms); 2, from Station 4722 (300–0 fathoms); 3, from Station 4607 (300–0 fathoms); 4, 5, 6, 8, from Station 4607 (surface); 7, from Station 4619 (surface); 9, from Station 4721 (300–0 fathoms); 10, from Station 4605 (300–0 fathoms); 11, from Station 4638 (300–0 fathoms); 12, from Station 4637 (300–0 fathoms).

as follows, if the *a*-rib is measured in a straight line to the margin of the list, and the *b*- to *e*-ribs are measured in straight lines to the points where they join the submarginal rib or, in the case of the absence of the last rib, to the beginning of the reticulations of the lobes: — the *a*-rib is 0.37 (0.28–0.53), the *b*-rib 0.52 (0.39–0.66), the *c*-rib 0.56 (0.41–0.74), the *d*-rib 0.57 (0.45–0.78), and the *e*-rib 0.59 (0.45–0.77) the greatest depth of the body. In the specimen figured by Jörgensen (1923, fig. 52), these ribs are somewhat longer; compare the measurements of the width of this list given above. In no case have less than five main radial ribs been found; but in a few specimens six or seven of them have been recorded; two *d*-ribs may be present, and in one specimen (Figure 83: 10) a further rib was developed next to the *e*-rib. An incomplete rib may be present between the *b*- and *c*-ribs, between the *c*- and *d*-ribs, and between the *d*- and *e*-ribs. In young specimens the radial ribs are simple, but soon they develop short branches, which probably increase in number and complexity with age.

The central portion of the hypotheca is areolate and porulate; the rest of the theca is porulate (Plate 16, fig. 1; Kofoid, 1907a, pl. 15, fig. 93). There is one pore in each areole. The areoles are of moderate and subuniform size. Phaeosomes of a rich greenish-yellow or olive-yellow color are often found in the transverse furrow; sometimes a few of these bodies are found attached to the left sagittal list. Specimens of normal and healthy appearance have been found completely lacking phaeosomes. The cytoplasm is of a reddish or geranium-pink tint and lacks every trace of chromatophores.

The dimensions of seventeen of our specimens and of the specimens figured by Stein (1883, pl. 23, fig. 3), Schütt (1900a, fig. 6), and Jörgensen (1923, fig. 52) were measured.

Dimensions: — Our specimens: Length of body, 54.8–67.6 μ (average, 62.4 μ). Greatest depth of body, 62.4–77.8 μ (average, 67.8 μ). The size of the type specimen (Schütt, 1900a, fig. 5) is unknown. The length of the specimen figured by Stein (1883, pl. 23, fig. 3) is also unknown. However, according to Stein's (1883) information about the magnifications of his figures given in an introductory remark to the explanations of the plates, it was somewhere between 42.0 and 64.5 μ. Schütt's (1900a, fig. 6) specimen was 65.0 μ long and 66.6 μ deep; Jörgensen's (1923, fig. 52), 64.5 μ long and 67.6 μ deep.

Variations: — The great majority of the recorded specimens show a fairly pronounced constancy in all characters. A few are subject to rather striking variations in the shape and structure of the left sulcal list. In some specimens the number of radial ribs in this list is six (Figure 83: 5, 7) or seven (Figure 83: 10),

or there may be, besides the normal number of five complete radial ribs, one more or less incomplete rib (Figure 83: 3, 4, 6, 11). Sometimes (Figure 83: 3, 4) the radial ribs are simple, but usually they are furnished with short, more or less developed branches. At least the *c*- and *d*-ribs may be branched proximally (Figure 83: 8). In one of our specimens (Figure 83: 9) the *d*-rib was very aberrant, its distal portion forming an irregular reticulum (due to regeneration following local injury?). The submarginal rib may be absent (Figure 83: 1–3) or present (Figure 83: 4–11); when present, it usually, but not always (Figure 83: 11), is exceedingly weak. Sometimes (Figure 83: 1; Jörgensen, 1923, fig. 52) the four lobes of this list are very pronounced; sometimes (Figure 83: 2) they are moderately developed; or they may be but slightly indicated (Figure 83: 10) or almost absent (Figure 83: 11). The variations in the development of the branches of the radial ribs are presumably due to age. The same appears to be true in regard to the submarginal rib. On the other hand, we do not know whether or not the established variations in the number of the ribs and in the development of the marginal lobes are due wholly to this cause, to resorption in adaptation to flotation, or to regulation following fission. It should be mentioned in this connection that in some recently divided specimens, probably belonging to this species, the left sulcal list had five well-developed and simple radial ribs behind the fission rib, and its posterior margin was almost evenly rounded, *i.e.*, without lobes. The twelve specimens of Figure 83, and the two represented by Plate **16**, figure 1, and by Kofoid (1907a, fig. 93) illustrate the range of variation exhibited by this species in the material of the Expedition. The great majority of our specimens (125, *i.e.* 74.0% out of the 169 that were carefully examined) agreed with the specimen represented by Figure 83: 2; sixteen specimens (9.5%) agreed with Figure 83: 4; seven (4.1%) with Figure 83: 3; five (3.0%) with Figure 83: 7; two (1.2%) with Figure 83: 5; two (1.2%) with Figure 83: 6; two (1.2%) with Figure 83: 2, but they had somewhat narrower left sulcal lists with slightly less marked lobes; one (0.6%) with Figure 83: 3, but without the short rib between the *b*- and *c*-ribs; one (0.6%) with Figure 83: 3, but with a short rib between the *c*- and *d*-ribs instead of between the *b*- and *c*-ribs; and of each of the forms represented by Figure 83: 1, 8, 9, 10, 11, 12, by Plate **16**, figure 1, and by Kofoid's (1907a) Plate 15, figure 93, only one specimen was found.

Comparisons: — The type specimen as figured by Schütt (1900a, fig. 5), as well as the specimen represented by Stein's (1883) Plate 23, figure 3, although young and thus not fully differentiated, are typical members of this species as conceived in the present paper. Schütt's (1900a) figure 6 is somewhat less repre-

sentative, having but slightly indicated lobes in the sulcal list, but its present allocation may be considered as fairly certain. Jörgensen's (1923, fig. 52) specimen is an unusually well-developed example of this species.

The typical members of this species (Figure 83: 2) are characterized especially by their left sulcal list, which is four-lobed, with or without an exceedingly fine submarginal rib, and with five complete radial ribs behind the fission rib. Of these five radial ribs the dorsal one, the *a*-rib, ends near the middle of the dorsal margin of this list, while each of the remaining four ends at the vertex of one of the four lobes. Besides these typical specimens several more or less aberrant ones have been assigned by us to this species. Our reasons for including these aberrant forms are the relatively great variability in several of the other species of this genus and the fact that the extremes appear to be connected with the typical ones by fairly complete series of intermediate specimens.

No specimens have been recorded as yet which are distinctly intermediate between *Ornithocercus steini* and any of the other species of this genus. Regarding the specimen represented by Figure 81: 11, of *O. thurni*, see the last species, the section on comparisons. The closest relative of *O. steini* appears to be *O. thurni*. The former species is easily distinguished from the latter by having four, instead of three lobes in the left sulcal list, by having the *a*-rib end at about the middle of the dorsal side of this list, and by having the *b*-rib end at the vertex of the dorsal lobe.

Synonymy: — This species was established by Kofoid (1907a) under the name of *Ornithocercus serratus* but had been figured previously by Stein (1883, pl. 23, fig. 3) and by Schütt (1900a, fig. 5, 6). Stein (1883, pl. 23, fig. 1–6) figured under the name of *O. magnificus* three different species. Schütt (1900a), who was the first to subdivide *O. magnificus* Stein, applied the name *O. magnificus s. str.* to Stein's (1883) Plate 23, figure 1, and the new name *O. steini* to Stein's (1883) Plate 23, figure 4. The species to which the last figure belongs had, however, previously been established by Schmidt (1888, pl. 144, fig. 59–61) as *Parelion thurnii*. The name *Ornithocercus steini* Schütt should therefore have been discarded as a synonym of *O. thurni* (Schmidt), had it not been for the fact that out of the three specimens figured by Schütt (1900a, fig. 5–7) as *O. steini* two are not referable to this species but to one later established by Kofoid (1907a) as *O. serratus*. Under these circumstances the name *O. steini s. str.* has to be maintained for these two specimens of Schütt (1900a) and *O. serratus* Kofoid must be rejected as a synonym. Stüwe (1909) recorded *O. steini s. str.* as *O. magnificus* var. *b*. Later this species was figured by Jörgensen (1923, fig. 52) as *O. serratus*.

Occurrence: — *Ornithocercus steini* is recorded at sixty-eight of the 127 stations. There are 16, 12, 1, 10, 19, and 10 stations on the six lines of the Expedition. Of these sixty-eight stations, one (4583) is in the California Current; ten (4587, 4590, 4592, 4598, 4600, 4604, 4605, 4607, 4545, 4546) are in the Mexican Current; fourteen (4609, 4611, 4613, 4615, 4617, 4619, 4623, 4634, 4635, 4637, 4638, 4639, 4640, 4644) are in the Panamic Area; five (4646, 4647, 4648, 4650, 4659) are in the Peruvian Current; one (4692) is in the Easter Island Eddy; four (4713, 4714, 4715, 4716) are in the Galapagos Eddy; twenty-seven (4701, 4704, 4705, 4709, 4711, 4712, 4717, 4718, 4719, 4720, 4721, 4722, 4723, 4724, 4727, 4728, 4729, 4730, 4731, 4732, 4733, 4734, 4736, 4737, 4739, 4740, 4741) are in the South Equatorial Drift; three (4742, 4743, 4540) are in the South Equatorial Current; two (4541, 4542) are in the Equatorial Counter Current; and one (4543) is in the North Equatorial Current. There are thirty-seven records from the surface (Stations 4590, 4592, 4600, 4604, 4607, 4611, 4615, 4617, 4619, 4623, 4635, 4638, 4639, 4640, 4644, 4646, 4648, 4692, 4704, 4712, 4714, 4716, 4718, 4720 [Salpa], 4723 [Salpa], 4727, 4729, 4731, 4733, 4741, 4743, 4540, 4541, 4542, 4543, 4545, 4546). At thirty-three of these thirty-seven stations the species was taken in surface waters only; at four stations (4590, 4617, 4638, 4646), in hauls from 300–0 fathoms as well as at the surface; at Stations 4619, 4712, and 4741, in Salpa stomachs as well as in surface hauls. At one station (4737) it is recorded from 100–0 fathoms and 300–0 fathoms; at one station (4713), from 150–0 fathoms and 300–0 fathoms; at five stations (4715, 4721, 4724, 4728, 4732), from 800–0 fathoms and 300–0 fathoms; at two stations (4647, 4717), from 800–0 fathoms only. All the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these sixty-eight stations at the surface was 69°–85°; the average was 77.5°. At the thirty-seven stations in the surface catches of which this species was found, the surface temperature ranged from 71° to 84°; the average was 77.8°.

For the surface catches the following frequencies are recorded: — 14% at one station (4607); 13% at one station (4543); 10% at one station (4545); 6% at one station (4600); 4% at four stations (4615, 4635, 4714, 4741); 3% at two stations (4640, 4546); 2% at five stations (4619, 4648, 4692, 4712, 4733); 1% at eleven stations (4590, 4604, 4617, 4638, 4639, 4716, 4720, 4729, 4731, 4541, 4542); in the remaining cases the frequency is less than 1%. For the catches from 100, 150, 300, or 800 fathoms to the surface the records of frequency are as follows: — 15% at one station (4598); 12% at one station (4613); 11% at one station (4721); 8% at two stations (4605, 4617); 7% at two stations (4638, 4722); 3% at two stations

(4634, 4637); 2% at two stations (4715, 4719); 1% at five stations (4711, 4724, 4732, 4736, 4737); at the remaining stations the frequency is less than 1%.

The type locality is unknown, but probably somewhere in the Atlantic Ocean. Stein (1883) figured one specimen "aus der Südsee" under the name of *Ornithocercus magnificus*. Stüwe (1909) found this species at two stations in the Atlantic, viz., at lat. 33° 29′ N., long. 21° 43′ W., and at lat. 4° 3′ N. and long. 26° 0′ W., in surface waters of 68.5°–82.8°. Faria and Cunha (1917) found it off Rio de Janeiro. Jörgensen (1923) recorded it from the Bay of Cadiz and from the eastern

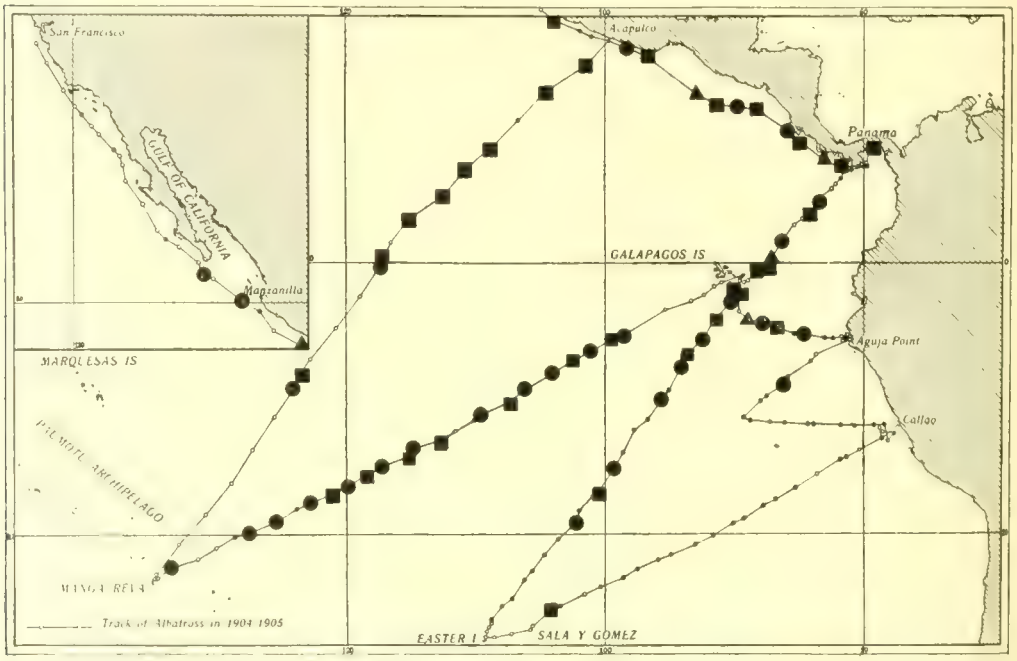

FIGURE 84.— Occurrence of *Ornithocercus steini* Schütt, *s. str.* Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

portion of the Mediterranean (the THOR Expedition) and stated that "it has been found, rarely, in the Florida Current, (30°–32° N., coast of America, May, 1910), far west of the Straits of Gibraltar (14° W., 29/8 1901) and in the Guinea Current 1/10 1903 (German South Pole Exped.) and fairly common in the southern Atlantic between South Africa and South America 11° W. to 38° W., 31° N. to 17° N. June to August 1911 ('Fram')." Kofoid (1907a) recorded this species from the Eastern Pacific, viz., from Stations 4613 and 4742 of the Expedition. See also the account of *Ornithocercus magnificus*.

Of the investigators who have contributed to our knowledge of the distribution of this species, Stein (1883), Kofoid (1907a), and Jörgensen (1923) give figures by means of which the determinations may be judged.

Ornithocercus steini is eupelagic and widely distributed in tropical, subtropical, and warm-temperate seas. In the Eastern Pacific it occurs in the whole area investigated by the Expedition but is strikingly rare in the Peruvian Current and in the Easter Island Eddy and is not recorded from the northern portion of the California Current; however, it occurs occasionally as far to the north as San Diego. Like most of the remaining species it is relatively frequent in surface waters, and the frequency percentages are on the average somewhat higher in the surface catches than in the vertical catches.

Ornithocercus orbiculatus Kofoid and Michener

Plate 17, fig. 7

Ornithocercus orbiculatus Kofoid & Michener, 1911, p. 300.

Diagnosis: — Lateral outline subcircular. Anterior cingular list 0.52, posterior 0.51 the greatest depth of body; anterior either with about twelve complete ribs and numerous short marginal ribs, or with a number of irregular ribs; posterior with about fifteen complete, simple ribs. Left sulcal list ends on dorsal side of body at posterior cingular list; margin subcircular, with small lobe dorsally; with five ribs, corresponding to *a*-, *b*-, *c*-, *d*-, and *e*-ribs in related species; *a*-rib reticulated distally, the remaining ribs irregular; width of list at *a*-rib 0.34, at *b*-rib 0.46, at *c*-rib 0.50, at *d*-rib 0.52, and at *e*-rib 0.49 the greatest depth of body; submarginal rib absent. Length of body, 66.6 μ.

Eastern tropical Pacific.

Description: — On account of the uncertain status of this species, we refrain from giving the usual elaborate specific description.

Dimensions: — Length of body, 66.6 μ. Greatest depth of body, 70.4 μ.

Comparisons: — Our diagnosis is based on the type specimen. This species undoubtedly is very closely related to *Ornithocercus steini*. Indeed, the only specimen observed as yet may even be an abnormal member of the mentioned species. We maintain *O. orbiculatus* tentatively, until further evidence is available. Kofoid and Michener (1911, p. 301) considered the type as "possibly a phase in thecal reconstruction."

Occurrence: — *Ornithocercus orbiculatus* has been recorded at only one of the 127 stations (4617), on the first line of the Expedition, in the Panamic Area, in surface waters of 78°, with a frequency of less than 1% (one specimen).

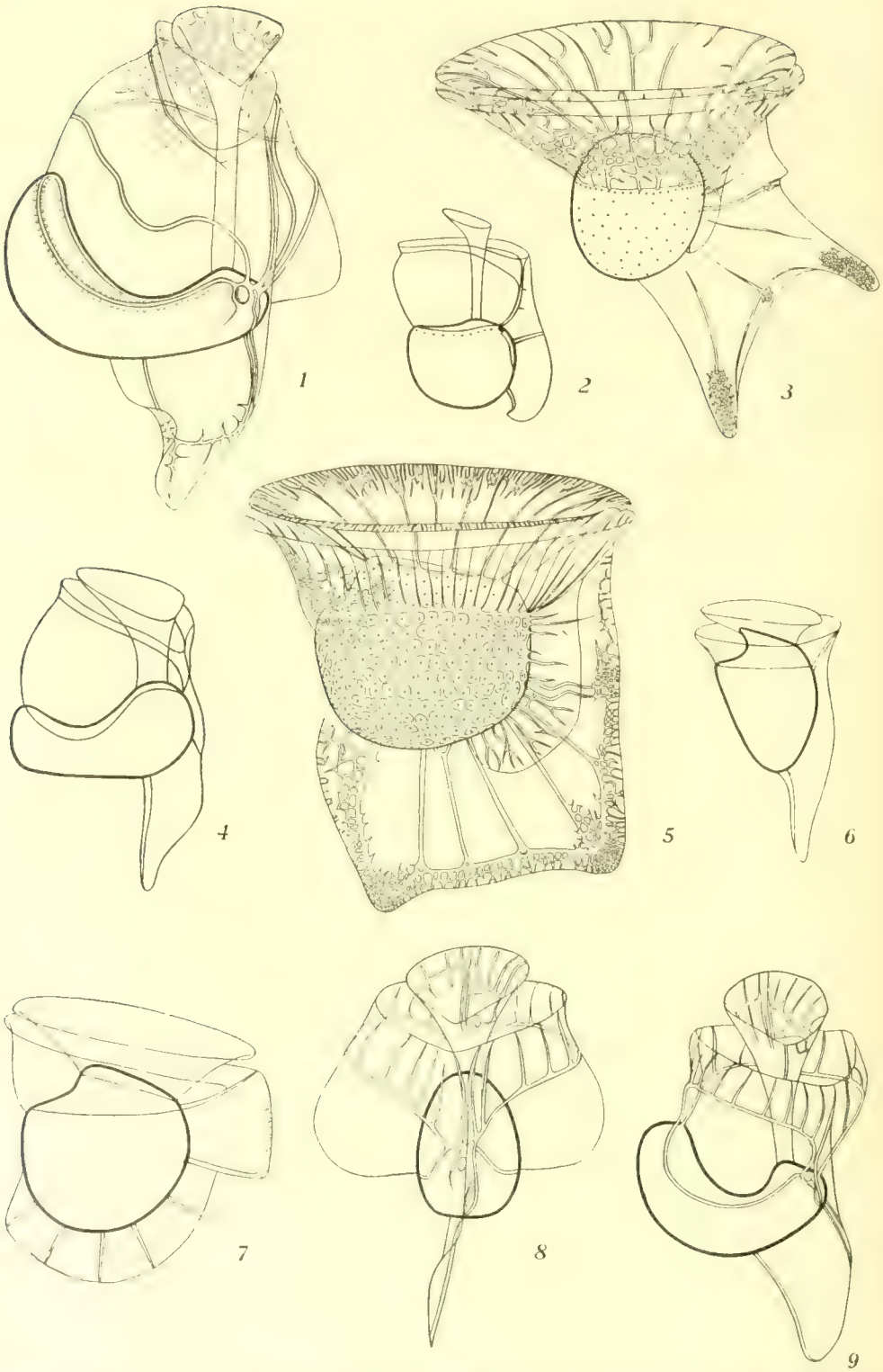

FIGURE 85.—1, *Histiocrs panda* Kofoid and Michener, oblique right lateral view of type specimen. × 935. Station 4724 (300 fathoms). 2, *Histiocrs ornata* Kofoid and Michener, right lateral view of type specimen. × 935. Station 4720 (Salpa). 3, *Ornithocercus splendidus* Schütt, right lateral

Ornithocercus quadratus Schütt

Plate 17, fig. 2, 8. Figure 85: 5, 86, 87, 88

? *Dinophysis galea* Pouchet, 1883, *partim*, p. 426, fig. G: 4.
Ornithocercus quadratus Schütt, 1900a, p. 5, 10, 17, 26, 27, fig. 1–4, 12, 13. Ostenfeld & Schmidt, 1901, p. 173. Karsten, 1906, p. 185, 186, 190, 193, 194, 195, 197, 198, 199, 200, 202, 203, 205, 206; 1907, p. 235, 237, 238, 240, 241, 249, 286, 288, 299, 302, 306, 307, 309, 312, 315, 318, 338, 341, 344, 346, 427, 447. Schröder, 1906a, p. 321, 326, 329, 333, 335, 339; 1909, p. 211; 1911, p. 12. Kofoid, 1907a, p. 206. Schiller, 1912, p. 27; 1912a. Gran, 1912b, p. 328. Jörgensen, 1923, p. 37, 38, fig. 50.
Histioneis magnifica Schröder, 1900a, p. 20, pl. 1, fig. 15.
Histioneis quadrata Lemmermann, 1901a, p. 376; 1904, p. 611, 643; 1905a, p. 37.
Histioneis magnificus var. *quadratus* Entz, 1902b, p. 94; 1905, p. 112 (as *magnifica* var. *quadrata*).
Ornithocercus magnificus var. *e* Stüwe, 1909, p. 235, 238, 239, 240, 242, 254, 275, 288.
Histioneis magnifica var. *quadrata* Forti, 1922, p. 114.
Ornithocercus assimilis Jörgensen, 1923, p. 37, fig. 51.

Diagnosis: — Lateral outline subcircular. Anterior cingular list 0.50–1.00, posterior cingular list 0.45–0.86 the greatest depth of body; inclination of these lists about the same as in *Ornithocercus steini*. Left sulcal list ends on dorsal side of body at a distance from the posterior cingular list equaling 0.37 (0.05–0.65) the greatest depth of body; either squarish or with two lobes, one of which is posteroventral, the other posterodorsal in position; width at posteroventral corner 0.58–1.10, at posterodorsal corner 0.53–0.88 the greatest depth of body; with three to eight ribs behind fission rib, and usually with submarginal rib; ribs very variable, sometimes with, sometimes without, branches. Length of body, 37.8–73.4 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — On account of the uncertain specific unity of this form, we have refrained from giving the usual elaborate specific description.

Dimensions: — Our specimens: Length of body, 64.0–37.8 μ. Greatest depth of body, 78.5–37.1 μ. In forma *quadrata* the corresponding values were 64.0–55.3 μ and 78.5–68.1 μ; in forma *schütti* they were 54.0–44.3 μ and 58.5–46.0 μ; in forma *assimilis*, 52.8–46.7 μ and 55.0–46.5 μ; in forma *simplex*, 45.2–43.0 μ and 43.4–42.0 μ; in forma *intermedia*, 45.0–37.8 μ and 42.9–37.1 μ. The type specimen (Schütt, 1900a, fig. 4) was 73.4 μ long and 82.7 μ deep. The specimens figured by Schröder (1900a, pl. 1, fig. 15) were only about 36.0 μ long and 40.1 μ

view. × 450. Station 4740 (300–0 fathoms). 4, *Histioneis carinata* Kofoid (?), right lateral view. × 450. Station 4681 (300–0 fathoms). 5, *Ornithocercus quadratus* Schütt f. *quadrata*, right lateral view. × 450. Station 4740 (300–0 fathoms). 6, *Parahistioneis para* (Murray and Whitting), right lateral view. × 450. Station 4699 (300–0 fathoms). 7, *Ornithocercus* sp., right lateral view of division stage, in which the left sulcal list of the right valve is in a state of development, and which shows that the lists of the old valve are not resorbed. × 450. Station 4619 (surface). 8, *Histioneis panaria*, sp. nov., ventral view of type specimen. × 935. Station 4724 (300–0 fathoms). 9, *Histioneis panaria*, sp. nov., oblique right lateral view of type specimen. × 935. Station 4724 (300–0 fathoms).

deep. Whether these specimens actually were so small or whether there is a mistake in the magnifications cannot be decided. It should be observed that according to the shape and structure these specimens appear to belong to forma *quadrata*. The specimen represented by Jörgensen's (1923) figure 50 (forma *quadrata*) was about 59.9 μ long and 60.5 μ deep; the one represented by Jörgensen's (1923) figure 51 (forma *assimilis*) was 44.4 μ long and 42.5 μ deep.

Variations: — *Ornithocercus quadratus*, as conceived in the present paper, is characterized by an extraordinary variability. It is indeed an eloquent example of Schütt's (1893, p. 269, 270) statement that in tropical waters "selbst die einzelnen Individuen desselben Typus weichen so weit von einander ab, dass es aussieht, als wollte jedes von ihnen sich als eigene Varietät etabliren." Almost every one of the characteristics used in distinguishing the species of this genus appears to be in a plastic, ever-changing condition in *O. quadratus*. Whether or not our decision to treat this multitude of forms as a single species is correct cannot be decided at the present time. We wish to emphasize, however, that our solution is regarded as tentative and that it is the result of many futile efforts at a usable and defensible subdivision. In Figures 86 and 87 the specimens have been arranged according to certain degrees of similarity. In the following discussion of these figures we shall first present the results of our attempts to classify our specimens and then give the reasons why the groups established have not been treated as independent species.

O. quadratus f. *quadrata:* — The specimens represented by Figure 86: 1–6, and by Figure 85: 5, form a distinct group, the specific unity of which appears to be beyond doubt in spite of the rather pronounced variations in the structure and shape of the left sulcal list. This group, which comprises also the type specimen (Schütt, 1900a, fig. 4) and the specimens represented by Schütt's (1900a) figure 3 and Jörgensen's (1923) figure 50, is characterized especially by the large size, by the gently concave or flat transverse furrow, and by the highly reticulated margin of the left sulcal list; it should also be mentioned that the radial ribs of this list often are furnished with short, more or less developed branches. The number of radial ribs in this list behind the fission rib ranges from five (Figure 86: 6) to eight (Figure 86: 2), six being the typical. The arrangement of these ribs is rather variable. The shape of the left sulcal list is also variable; sometimes, *e.g.*, in the type specimen (Schütt, 1900a, fig. 4), in Jörgensen's (1923) figure 50, and in our Figure 86: 1, this list is squarish and comparatively broad; sometimes (Figure 86: 4) its posterior margin is characterized by a fairly well-developed antapical lobe, in other words, its posterior portion is rather distinctly three-lobed; some-

times (Figure 86: 3) it is relatively narrow and has two pronounced posterior lobes, its postmargin being strikingly concave. To this group belonged fifty-seven (*i.e.*, 18.7%) out of the 305 specimens of this species that were carefully examined by us. Out of these fifty-seven specimens not less than thirty-seven (64.9%) agreed with Figure 86: 5; eight (14.0%) also resembled Figure 86: 5, but their left sulcal list had the postmargin somewhat straighter, an extra rib was developed between the fission rib and the rib ending near the posteroventral corner (as in Figure 86: 4), and in some of these specimens the margin outside the submarginal rib was very narrow; 4 (7.0%) agreed with Figure 86: 3, but their left sulcal list had the postmargin shaped as in Figure 86: 2, and its submarginal rib was marginal; one (1.8%) agreed with Figure 86: 3, but all the ribs of the left sulcal list were complete; one (1.8%) agreed with Figure 86: 4, but its left sulcal list had the ribs ending near the antapical and posteroventral lobes incomplete, and its antapical lobe was slightly less developed; of each of the forms represented by Figure 86: 1, 2, 3, 4, 6, and by Figure 85: 5, only one specimen was found.

O. quadratus f. *schütti:* — A second, fairly distinct group is formed by the specimens represented by Figure 86:7–14, and by Plate 17, figure 8. In the case of these specimens, too, the unity appears to be certain, although striking variations occur. This group, which also includes Schütt's (1900a) figure 2, is characterized mainly by the intermediate size, by the gently or moderately concave transverse furrow, and by the shape and structure of the left sulcal list. This list is squarish; the margin outside its submarginal rib is comparatively narrow, and either plain or furnished with but slightly developed structural differentiations; and its ribs are nearly always simple, in other words, without branches. The number of radial ribs in this list behind the fission rib ranges from three (Figure 86: 14) to seven (Figure 86: 7), six being the normal, and it evidently increases with age as in the case of *Ornithocercus magnificus* and *O. thurni*. The arrangement of these ribs is variable; *e.g.*, in some specimens (Figure 86: 12) one of these ribs ends at the posteroventral corner of this list, while in others (Plate 17, fig. 8) this corner lacks ribs. The posterior margin of this list sometimes (Figure 86: 11) is nearly straight, sometimes moderately convex (Figure 86: 7) or concave (Figure 86: 12); a slight indication of an antapical lobe may also be present. To this group belonged 145 (47.6%) out of the 305 specimens of this species that were carefully examined by us. Out of these 145 specimens seventy-eight (53.8%) agreed with Figure 86: 8; twenty-three (15.9%) agreed with Figure 86: 10; twenty-two (15.2%) with Figure 86: 7; eight (5.5%) with Figure 86: 14; five (3.4%) with Figure 86: 8, but their left sulcal list had an extra, incomplete rib between the

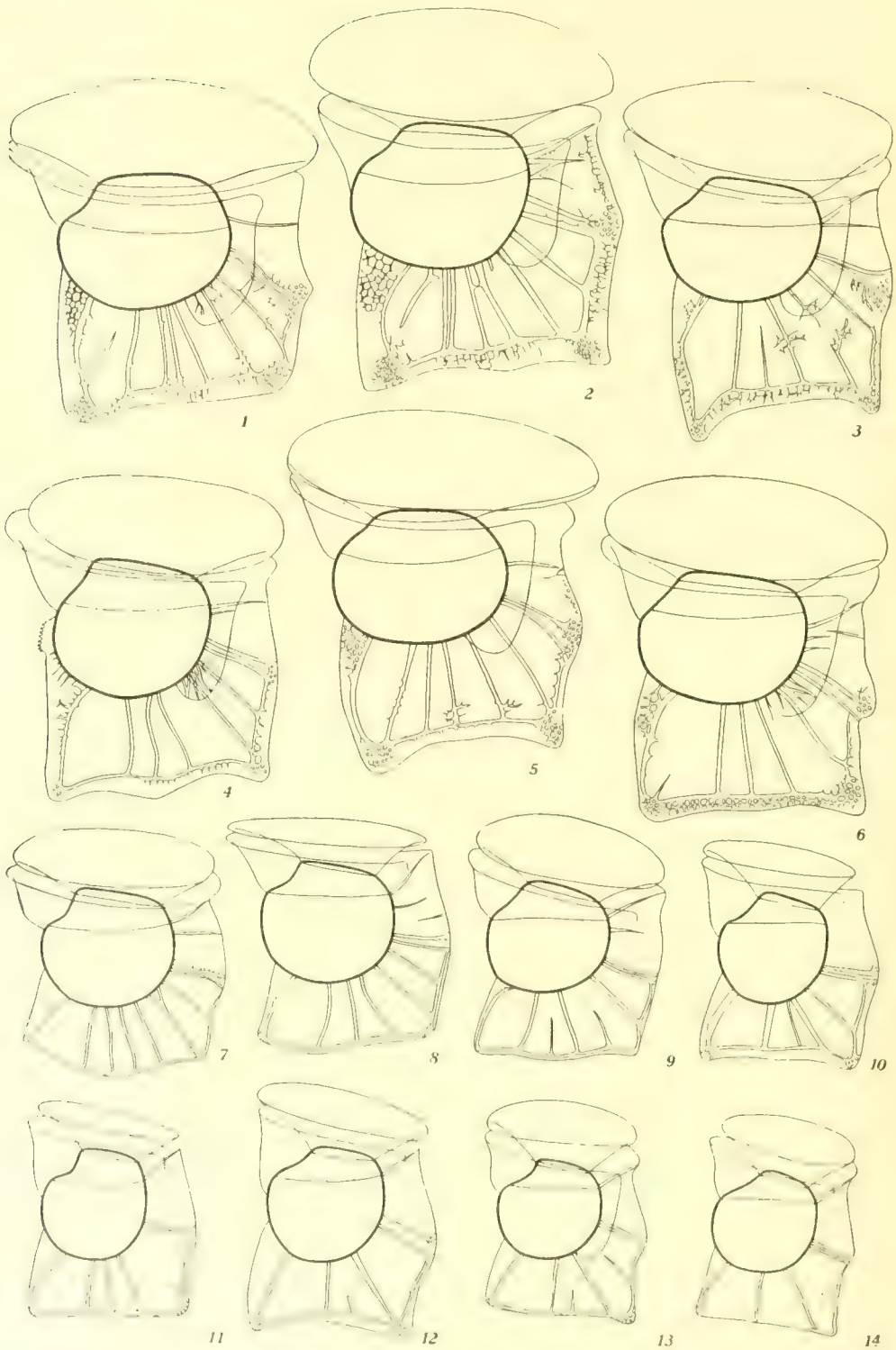

FIGURE 86.— *Ornithocercus quadratus* Schütt, right lateral view, illustrating variations in size of body and in shape and structure of left sulcal list. × 340. 1–6 belong to forma *quadrata*; 7–14, to f. *ebria*, f. nov. 1, 5, from Station 4687 (300–0 fathoms); 2, from Station 4742 (300–0 fathoms); 3, 13, from Station 4737 (100–0 fathoms); 4, 7, 8, from Station 4722 (300–0 fathoms); 6, 9, from Station 4740 (300–0 fathoms); 10, 14, from Station 4732 (300–0 fathoms); 11, from Station 4701 (300–0 fathoms); 12, from Station 4730 (300–0 fathoms).

dorsal rib and the three antapical ribs, the margin outside its submarginal rib was somewhat broader and had a slight reticulation, and its postmargin was more lobed in the middle; two (1.4%) agreed with Figure 86: 9; one (0.7%), with Figure 86: 8, but it lacked the submarginal rib in the left sulcal list; one (0.7%), with Figure 86: 8, but it lacked the submarginal rib and the radial rib to the posteroventral corner of the left sulcal list; one (0.7%) agreed with Figure 86: 9, but its left sulcal list lacked the submarginal rib, and its radial ribs were complete; there was only one specimen of each of the forms represented by Figure 86: 11, 12, 13, and by Plate 17, figure 8.

O. quadratus f. *assimilis* (Jörgensen): — A third group, the unity of which is equally probable, is formed by the specimens represented by Figure 87: 1–8. This group, which includes also Jörgensen's (1923, fig. 51) *Ornithocercus assimilis*, may be characterized as follows. The size is intermediate. The transverse furrow is flat or gently convex. The left sulcal list is squarish and nearly as wide dorsoventrally as in the second group. The margin of this list outside the submarginal rib is of a moderate width and as a rule not structurally differentiated except dorsally to the dorsal rib and at the corners where it often is reticulated. The radial ribs behind the fission rib, the number of which varies (with age?) from five (Figure 87: 7) to eight (Figure 87: 1), usually are furnished with short, more or less developed branches, or their proximal ends may be connected by reticular anastomoses (Figure 87: 1, 2). Their arrangement is variable; for instance, sometimes (Figure 87: 2) one of them ends at the posteroventral corner of this list, while in other cases (Figure 87: 6) this corner lacks ribs. The distal end of the posterior fission rib generally is bent posteriorly, joining the submarginal rib (Figure 87: 5, 6; Jörgensen, 1923, fig. 51). The posterior margin of this list sometimes (Figure 87: 3) is nearly straight, sometimes (Figure 87: 1) gently convex, and sometimes (Figure 87: 5, 6) it has an indication of an antapical lobe. To this group belonged only twenty-nine (9.5%) out of the 305 specimens of this species that were carefully examined by us. Out of these twenty-nine specimens twelve (41.4%) agreed with Figure 87: 7; ten (34.4%) agreed with Figure 87: 8; two (6.9%) with Figure 87: 2; and of each of the forms represented by Figure 87: 1, 3, 4, 5, 6, there was only one specimen.

O. quadratus f. *simplex*, nov.: — A fourth and quite distinct group is formed by the specimens represented by Figure 87: 11–13 and by Plate 17, figure 2. This group is characterized especially by the relatively small size, by the gently convex transverse furrow, and by the shape and the structure of the left sulcal list. This list is squarish and relatively narrow when compared to this structure in the previ-

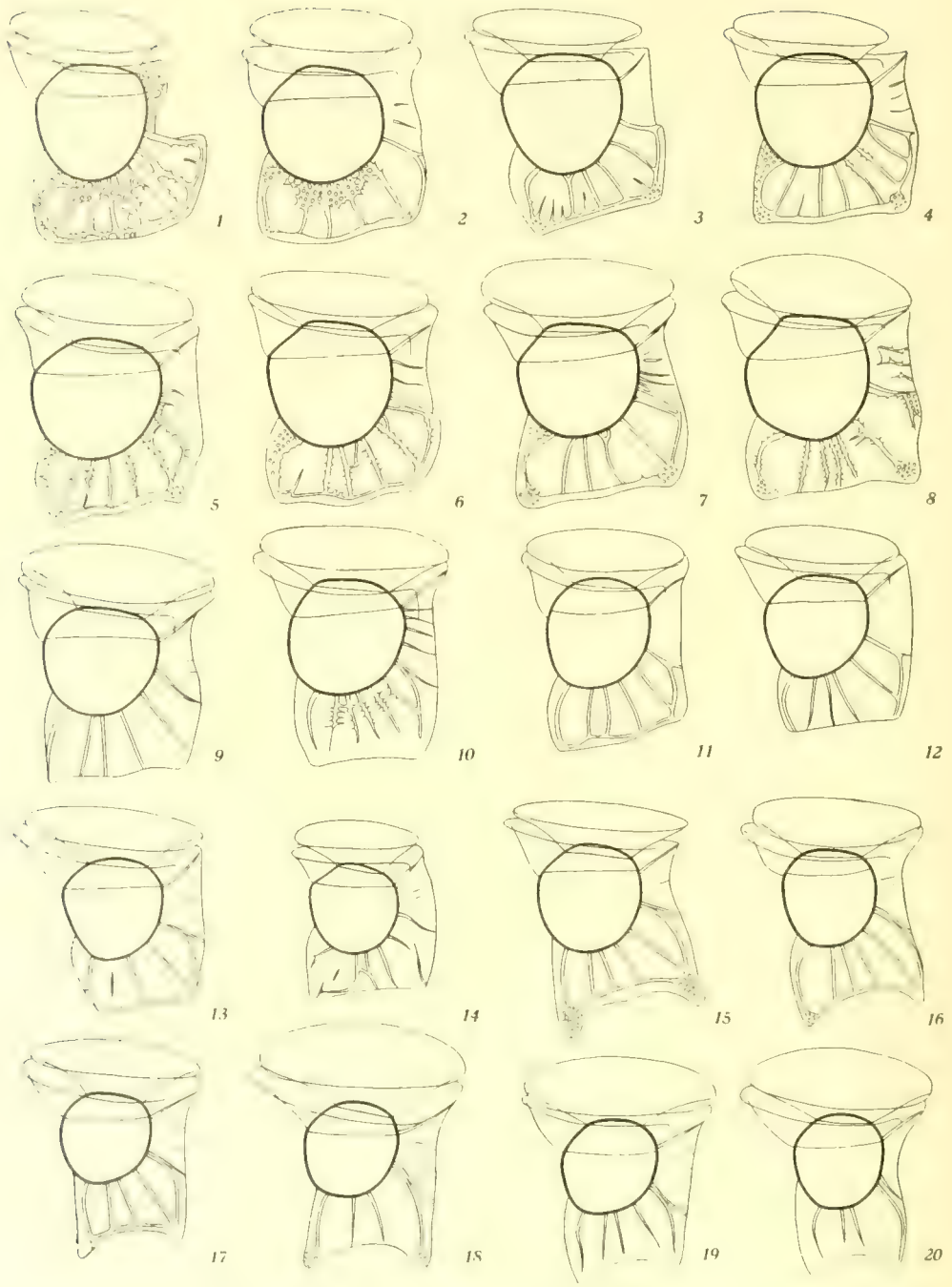

FIGURE 87.— *Ornithocercus quadratus* Schütt, right lateral view, illustrating variations in size of body and in shape and structure of left sulcal list. × 340. 1–8 belong to forma *assimilis* (Jörgensen); 11–13, to f. *simplex*, f. nov.; 15–20, to f. *intermedia*, f. nov.; 9, 10, 14 are of uncertain allocation. 1, 3, 6, from Station 4638 (300–0 fathoms); 2, from Station 4605 (300–0 fathoms); 4, 7, 8, from Station 4607 (surface); 5, 14, from Station 4619 (surface); 9, from Station 4713 (300–0 fathoms); 10, 11, 12, from Station 4681 (300–0 fathoms); 13, from Station 4722 (300–0 fathoms); 15, from Station 4732 (300–0 fathoms); 16, 18, from Station 4737 (300–0 fathoms); 17, 19, 20, from Station 4730 (300–0 fathoms).

ous groups. The margin outside its submarginal rib, when this is present, is fairly narrow and lacks structural differentiation. Its ribs appear always to be simple, in other words, to lack branches. The number of the radial ribs behind the fission rib ranges from three (Figure 87: 13) to five (Figure 87: 11, 12); presumably these ribs increase in number with age. At least in some specimens (Figure 87: 13) the distal portion of the fission rib is bent backward. The postmargin of this list is nearly straight. To this group belonged sixty-one (20.0%) out of the 305 specimens of this species carefully examined by us. Out of these sixty-one specimens not less than fifty-one (83.5%) agreed with Figure 87: 12; seven (11.5%) resembled Figure 87: 13, fairly closely; two (3.3%) agreed with Figure 87: 11; and one (1.6%) with Plate 17, figure 2.

O. quadratus f. *intermedia*, nov.: — A fifth, and last, group is made up of the specimens represented by Figure 87: 15–20. Although quite pronounced variations occur within this group, it forms a fair unit. It is characterized chiefly by the relatively small size, by the gently convex or flat transverse furrow, and by the shape and structure of the left sulcal list. This list is strikingly bilobed, its postmargin being of pronounced concavity and relatively narrow dorsoventrally. The margin outside the submarginal rib, when this is present, is of moderate width (Figure 87: 15) or narrow (Figure 87: 16, 17), and it lacks structural differentiation except in the two lobes, which sometimes are reticulated (Figure 87: 15). Its ribs are always simple, *i.e.*, lack branches. The number of radial ribs behind the fission rib is from three (Figure 87: 18, 20) to five (Figure 87: 15, 16). The distal portion of the fission rib is curved backward. To this group belonged only eight (2.6%) of the 305 specimens of this species that we examined carefully. Two of these eight specimens agreed with Figure 87: 19; one more resembled this figure, but the postmargin of the left sulcal list was but slightly concave; and of each of the forms represented by Figure 87: 15, 16, 17, 18, 20, only one specimen was found.

The specimens represented by Figure 87: 9, 10, 14, are of uncertain allocation. The form represented by Figure 87: 9, of which three specimens are recorded, resembles the specimens of the third group in the shape of the body and in the shape of the left sulcal list; in the simplicity of the radial ribs of this list, on the other hand, it agrees with the specimens of the second group. The specimen of Figure 87: 10, embodies characteristics of the third, fourth, and fifth groups. It resembles the specimens of the third group in having the radial ribs of the left sulcal list furnished with short branches; the shape of this list recalls the fourth group; and the shape of the posterior fission rib suggests relationship to the

fifth group. The specimen of Figure 87: 14 presumably is abnormal. It approaches most closely the fourth group, but the radial ribs of the left sulcal list behind the fission rib are very irregular (possibly due to regeneration following damage).

Unfortunately, we are not able to give a complete account of the distribution of these five forms in the area investigated by the Expedition, since a fairly great number of our specimens were not identified to forma. However, since the distribution of the 305 specimens of this species that were carefully examined by us shows certain interesting and possibly indicative features, it will be presented. The fifty-seven specimens of forma *quadrata* were restricted to the South Equatorial Drift and the South Equatorial Current. Two of them occurred at Station 4687, the remaining ones were taken at Stations 4709, 4721, 4722, 4724, 4730, 4732, 4736, 4737, 4740, and 4742; most of them (36) were found at Station 4740. The 145 specimens of forma *schütti* were found at the following stations: 4605, 4607, 4638, 4679, 4697, 4701, 4709, 4713, 4721, 4722, 4730, 4732, 4736, 4737, 4740, and 4742. In other words, most of them were recorded from the South Equatorial Drift, but some were taken in the Mexican Current, Panamic Area, Easter Island Eddy, Galapagos Eddy, and South Equatorial Current. This form was most common at Stations 4701, 4707, 4709, 4721, 4722, and 4740. The twenty-nine specimens of forma *assimilis* occurred at Stations 4605, 4607, 4619, 4638, 4713, and 4737; in other words, in the Mexican Current, Panamic Area, Galapagos Eddy, and South Equatorial Drift. Most of these specimens were found in the Mexican Current and the Panamic Area. The sixty-one specimens of forma *simplex* were taken at Stations 4605, 4607, 4638, 4681, 4691, 4695, 4697, 4701, 4713, 4722, 4724, 4730, 4732, 4737, 4740, and 4742; *i.e.*, they were fairly evenly distributed in the area occupied by forma *schütti*. The eight specimens of forma *intermedia* were restricted to three stations in the eastern portion of the South Equatorial Drift, viz., to Stations 4730, 4732, and 4737. According to these data, therefore, two of these five forms, viz., forma *schütti* and forma *simplex*, appear to be fairly uniformly distributed over the area occupied by the species; two, viz., forma *quadrata* and forma *intermedia*, appear to have their center of distribution in the eastern portion of the South Equatorial Drift; and one, forma *assimilis*, appears to predominate in the Mexican Current and the Panamic Area.

Our reasons for treating these five forms as formae and not as distinct species are as follows: — (*1*) Differences in size appear to be of little consequence in this genus, due to the peculiar mode of division illustrated by Plate 18. (*2*) The structure and shape of the left sulcal list are strikingly variable also within other spe-

cies of this genus. This list appears to change quite readily in response to changes in the surrounding medium; and the area investigated by the Expedition is very large, includes regions of quite different physical conditions, and some of these regions are very turbulent. (*3*) Forma *schütti*, f. *assimilis*, f. *simplex*, and f. *intermedia* are not clear-cut units, but all their characteristics show overlapping variations. Intermediate specimens sometimes are found, the allocation of which is uncertain.

On the other hand, it cannot be too strongly emphasized that there are fairly good reasons in favor of the systematic independence of these forms. First, the variations exhibit distinct modes corresponding to these formae. For instance, out of the fifty-seven specimens of f. *quadrata* not less than thirty-seven (64.9%) agreed quite well with Figure 86: 5; and out of the 145 specimens of f. *schütti* seventy-eight (53.8%) agreed with Figure 86: 8. Second, the distribution of these forms also appears to support the assumption of systematic differentiation. It is far from impossible that we are concerned here with the incipient stages of speciation.

Comparisons: — The type specimen as figured by Schütt (1900a, fig. 4), as well as the specimens represented by Schröder's (1900a) Plate 1, figure 15, and by Jörgensen's (1923) figure 50, resemble our Figure 85: 5; Schütt's (1900a) figures 2 and 3 agree fairly well with our Figure 86: 8 and Figure 86: 4, respectively; and Jörgensen's (1923, fig. 51) figure of *Ornithocercus assimilis* approaches rather closely our Figure 87: 7. On the other hand, we have not found any specimens with the posteroventral corner of the left sulcal list as well rounded as in Schütt's (1900a) figure 1.

The closest-known relative of *Ornithocercus quadratus* appears to be *O. thurni*. The former species is easily distinguished from the latter by its squarish or two-lobed left sulcal list, although this list may have a fairly well-developed middle (antapical) lobe (Figure 86: 4). It also should be mentioned that *O. quadratus* f. *intermedia* is almost intermediate between this species and *O. splendidus* in the shape of the left sulcal list. This list of this forma also recalls *O. heteroporus*.

Synonymy: — This species was established by Schütt (1900a) under the name of *Ornithocercus quadratus*. In the same year it was figured by Schröder (1900a) as *Histioneis magnifica*. Ostenfeld and Schmidt (1901), Karsten (1906, 1907), Schröder (1906a, 1909, 1911), Kofoid (1907a), Schiller (1912, 1912a), Gran (1912b), and Jörgensen (1923) either record or mention this species under the name applied by Schütt (1900a); of these investigators only Jörgensen (1923) gives any figure. Lemmermann (1901a, 1904, 1905a) uses the name *Histioneis*

quadrata; Entz (1902b) uses *H. magnificus* var. *quadratus;* Entz (1905) and Forti (1922) use *H. magnifica* var. *quadrata;* Stüwe (1909) uses *Ornithocercus magnificus* var. *e;* none of these investigators gives any figures. Under the name of *Dinophysis galea* Pouchet (1883, p. 426) figures four specimens, one of which (fig. G: 4) resembles this species but is not so figured as to permit positive identification. *Ornithocercus assimilis* Jörgensen (1923, p. 37, fig. 51), which by its author was considered as possibly a "form" of *O. quadratus,* has in the present paper been included in this species.

Occurrence: — *Ornithocercus quadratus* is recorded at seventy-six of the 127 stations. There are 17, 11, 8, 11, 19, and 10 stations on the six lines of the Expedition. Of these seventy-six stations, two (4580, 4583) are in the California Current; thirteen (4587, 4588, 4590, 4592, 4594, 4596, 4598, 4600, 4604, 4605, 4607, 4545, 4546) are in the Mexican Current; eleven (4609, 4615, 4617, 4619, 4631, 4634, 4635, 4637, 4638, 4639, 4640) are in the Panamic Area; four (4646, 4647, 4650, 4671) are in the Peruvian Current; five (4689, 4691, 4695, 4697, 4699) are in the Easter Island Eddy; two (4713, 4715) are in the Galapagos Eddy; thirty-three (4679, 4681, 4682, 4683, 4685, 4687, 4701, 4705, 4707, 4709, 4711, 4712, 4717, 4718, 4719, 4720, 4721, 4722, 4723, 4724, 4725, 4728, 4729, 4730, 4731, 4732, 4733, 4734, 4736, 4737, 4739, 4740, 4741) are in the South Equatorial Drift; three (4742, 4743, 4540) are in the South Equatorial Current; two (4541, 4542) are in the Equatorial Counter Current; and one (4543) is in the North Equatorial Current. There are thirty-three records from the surface (Stations 4583, 4588, 4592, 4596, 4600, 4604, 4607, 4615, 4617, 4619, 4631, 4635, 4638, 4639, 4640, 4682, 4709 [Salpa], 4712, 4718, 4720 [Salpa], 4723 [Salpa], 4725, 4729, 4731, 4733, 4741, 4743, 4540, 4541, 4542, 4543, 4545, 4546). At twenty-nine of these thirty-three stations the species was taken in surface waters only; at three stations (4583, 4617, 4638), in hauls from 300–0 fathoms as well as at the surface; at one station (4709), in a haul from 300–0 fathoms as well as from a Salpa; at Stations 4619 and 4725, in Salpa stomachs as well as in surface hauls. At one station (4737) it is recorded from 100–0 fathoms and 300–0 fathoms; at eight stations (4681, 4701, 4715, 4717, 4721, 4724, 4728, 4732) from 800–0 fathoms and 300–0 fathoms; at one station (4647) from 800–0 fathoms only. All the remaining records refer to hauls from 300–0 fathoms only.

The species was taken also in surface waters in Acapulco Harbor, off the Mexican Current. This station is not included in the 127 stations mentioned above.

The temperature range of these seventy-six stations at the surface was 66°–

85°; the average was 77.0°. At the thirty-three stations in the surface catches of which this species was found, the surface temperature ranged from 69° to 84°; the average was 78.8°. At Acapulco it was 83°.

For the surface catches the following frequencies are recorded: — 15% at one station (4607); 8% at one station (4543); 6% at two stations (4604, 4546); 4% at three stations (4619, 4638, 4720); 3% at three stations (4600, 4615, 4545); 2% at one station (4741); 1% at six stations (4596, 4640, 4731, 4733, 4541, 4542); in the remaining cases the frequency is less than 1%. For the catches from 100, 300, or 800 fathoms to the surface the records of frequency are as follows: — 10% at two stations (4740, 4742); 8% at one station (4728); 7% at two stations (4638, 4721); 5% at one station (4724); 4% at three stations (4590, 4605, 4722); 3% at two stations (4634, 4681); 2% at seven stations (4580, 4587, 4689, 4691, 4701, 4709, 4730); 1% at sixteen stations (4583, 4594, 4617, 4637, 4695, 4697, 4699, 4705, 4707, 4715, 4717, 4732, 4734, 4736, 4737, 4739); at the remaining stations the frequency is less than 1%. For the catch made in Acapulco Harbor a frequency of less than 1% is recorded.

The type locality of this species is unknown. Karsten (1906) found the species at sixteen stations in the Atlantic, between lat. 8° 58′ N. and lat. 5° 47′ S., and between long. 16° 27′ W. and long. 8° 4′ E.; Stüwe (1909) at fifteen stations in the Atlantic, between lat. 34° 53′ N. and lat. 3° 50′ N., and between long. 20° 22′ W. and long. 40° 16′ W.; Schröder (1909) in the West Indies; Jörgensen (1923) off the east coast of America, between lat. 30° N. and lat. 36° N., at lat. 30° S., long. 13° W., and on the southwest coast of Portugal. In the Mediterranean it has been found by the following investigators: — Pouchet (1883) [?] in the Gulf of Lyons; Schröder (1900a) in the Gulf of Naples; Entz (1902b, 1905), Schröder (1906a), and Schiller (1912, 1912a) in the Adriatic Sea; Jörgensen (1923) at several stations, nearly all of which were located in the eastern portion of the Mediterranean. In the Red Sea and in the Gulf of Aden it has been found by Ostenfeld and Schmidt (1901); in the Arabian Sea by Schröder (1906a) and Jörgensen (1923); in the Indian Ocean by Schröder (1906a), and by Karsten (1907) who recorded it from nineteen stations, between lat. 32° 53′ S. and lat. 9° 6′ N. and between long. 45° 29′ E. and long. 98° 21′ E.; in the East Indies, in the South China Sea, and in Japanese waters by Schröder (1906a); and between Laysan Island and Hawaii by Lemmermann (1904).

Most of the records referred to in the last paragraph were from surface hauls. Only one closing-net record has been published as yet, viz., from Station 229 of the Valdivia Expedition, lat. 2° 38′ S., long. 63° 37′ E., 200–20 m., dead (Karsten, 1907).

Stüwe (1909) found this species in waters ranging from 65.5° to 82.7°.

Of the investigators who have contributed to our knowledge of the distribution of this species, only Pouchet (1883), Schröder (1900a), and Jörgensen (1923) give figures by means of which their determinations may be checked.

Ornithocercus quadratus is eupelagic and widely distributed in tropical, subtropical, and warm-temperate waters. In the Eastern Pacific it occurs in the

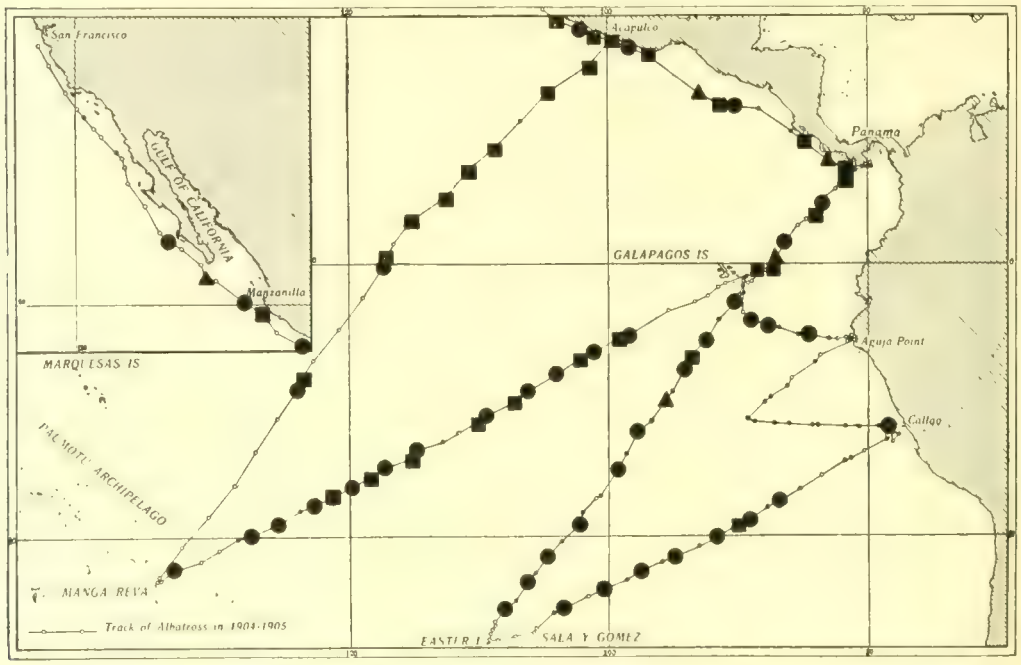

FIGURE 88.— Occurrence of *Ornithocercus quadratus* Schütt. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; triangles, records from both vertical and surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

whole area investigated by the Expedition, but it is strikingly rare in the Peruvian Current. It is not recorded from the northern portion of the California Current but occurs occasionally as far to the north as San Diego, California. It is one of the most common species of Dinophysoidae. See also the section on variations.

ORNITHOCERCUS CAROLINAE Kofoid

Plate 17, fig. 1, 6. Figure 89, 90

Ornithocercus carolinae KOFOID, 1907a, p. 205, pl. 15, fig. 92. JÖRGENSEN, 1923, pl. 38, fig. 53.

Diagnosis: — Lateral outline subcircular. Cingular lists: anterior 0.46–0.67, posterior 0.43–0.58 the greatest depth of body; anterior with 12–19 complete ribs, sometimes with basal and distal anastomoses, and a number of short, marginal

ribs; posterior with 14–19 complete, simple ribs, some of which may be connected by anastomoses. Left sulcal list ends on dorsal side of body, 0.37–0.71 the greatest depth of body from posterior cingular list; with three lobes, one of which is posteroventral, one posterior, and one posterodorsal; the posterior larger than the others and usually narrowly rounded; width at posteroventral lobe (= fission rib) 0.34–0.73, at posterior lobe 0.65–1.11, at posterodorsal lobe 0.27–0.59 the greatest depth of body; with 11–15 radial ribs behind fission rib and usually with reticulation in posterodorsal and posterior lobes. Submarginal rib may be present. Length, 30.5–52.0 μ.

Widely distributed in tropical, subtropical, and warm-temperate seas.

Description: — This is a medium-sized or small species, subrotund in lateral outline, deepest at or near the middle. The ratio between the length and the depth of the body is 0.98 (0.91–1.07) : 1. The longitudinal axis may be perpendicular to the posterior cingular list, but usually it is deflected posterodorsally at 1°–10°.

The epitheca is 0.49 (0.38–0.64) as deep as the hypotheca, slightly convex or almost flat, highest in the center or dorsally, and sometimes subhorizontal but usually tilted ventroposteriorly at 5°–12°. The transverse furrow is gently concave or nearly flat; its dorsal width is 0.42 (0.36–0.46) the greatest depth of the body; its ventral width is 0.56 (0.45–0.70) its dorsal width. The posterior cingular list is 0.29 (0.22–0.36) the length of the body from the apex. The dorsal, posterior, and ventral margins of the hypotheca are well rounded and confluent; or any of them may be slightly flattened. In dorsoventral view the body is subellipsoidal, well rounded posteriorly, subacute anteriorly, widest in the middle, and 1.6 times longer than wide.

The anterior cingular list is 0.59 (0.46–0.67) the greatest depth of the body and has an anterior inclination of 35° (25°–45°); it has on each valve 12–19 complete ribs, which may be connected by anastomoses basally as well as distally, and a varying number of short, marginal radial ribs. The posterior cingular list is 0.53 (0.43–0.58) the greatest depth of the body and is inclined anteriorly at 65° (50°–85°); it has on each valve 14–19 complete, simple radial ribs, some of which may be connected by anastomoses (Jörgensen, 1923, fig. 53). The right sulcal list is fairly large, ending at about the third or fourth rib behind the fission rib of the left sulcal list; its anterior half is of subuniform width; posteriorly its width decreases gradually; in the middle its width is about 0.17–0.20 the greatest depth of the body; it may be furnished with some ribs that may anastomose. The left sulcal list ends on the dorsal side of the body at a distance from the posterior

cingular list equaling 0.51 (0.37–0.71) the greatest depth of the body and is characterized by three usually well-developed lobes, one of which is posteroventral, one posterior, and one posterodorsal in position. The posterior of these lobes, which always is larger than the others, usually is narrowly rounded. The posteroventral and posterodorsal lobes also are narrowly rounded in most specimens, but the former may be but slightly indicated and the latter may be subrectangular. In our specimens the width of this list at the anterior main rib is 0.46 (0.37–0.56), at the posteroventral lobe (*i.e.*, at the fission rib) 0.53 (0.34–0.73), at the posterior lobe 0.80 (0.65–1.03), and at the posterodorsal lobe 0.43 (0.27–0.59) the greatest depth of the body. In the specimen figured by Jörgensen (1923, fig. 53), which had the posterior lobe better developed than in any of our specimens, the width at this lobe was 1.11 the greatest depth of the body. The margin between the anterior main rib and the fission rib may be nearly straight, but usually it is gently concave. Between the tip of the posterior lobe and the tips of the posteroventral and posterodorsal lobes, the posterior margin usually is moderately or rather strongly concave, but the margin between the posteroventral and posterior lobes may be nearly straight or even gently convex. The dorsal margin of this list is gently convex or nearly straight. In front of the fission rib this list has a varying number of ribs which may be partly connected by anastomoses. The fission rib ends in the posteroventral lobe. Behind the fission rib there are 11–15 radial ribs, some of which may be branched proximally. The dorsal one of these ribs is somewhat stronger than the others and ends in the posterodorsal lobe. Sometimes the bases of these ribs are connected by reticulation. In the posterodorsal and posterior lobes and dorsally to the dorsal radial rib reticulation is usually present. Reticulation may also be developed in the posteroventral lobe. A submarginal rib may be present along the posterior margin.

The thecal wall has numerous pores; on the hypotheca each of these is surrounded by a small areole. Near the middle of the body there are about 10–17 areoles across the face of each valve. The areoles bordering the transverse furrow posteriorly are somewhat larger than the rest. Small, ellipsoidal or ovate, greenish-yellow phaeosomes may be present in the transverse furrow; sometimes their number is very large. The cytoplasm is pink.

The dimensions of fourteen of our specimens, including the type, and of the specimen figured by Jörgensen (1923, fig. 53) were measured.

Dimensions: — Our specimens: Length of body, 30.5–52.0 μ (average, 41.9 μ; type, 44.9 μ). Greatest depth of body, 31.9–57.0 μ (average, 42.9 μ; type, 49.4 μ). The specimen figured by Jörgensen (1923, fig. 53) was 47.5 μ long and 49.0 μ deep.

Variations: — Most of the members of this species (Figure 89: 1–4), although exhibiting a remarkable variability in size, are structurally rather constant. However, since we have been forced to include some specimens deviating very considerably from these typical ones, the range of variation of the species as a whole is quite pronounced. Next to the size of the body, the most variable characters are the shape and structure of the left sulcal list. The posterior lobe of this list is usually rather narrowly rounded, but it may be subrectangular (Figure 89: 7). The posteroventral lobe is in most cases very well developed, due to the pro-

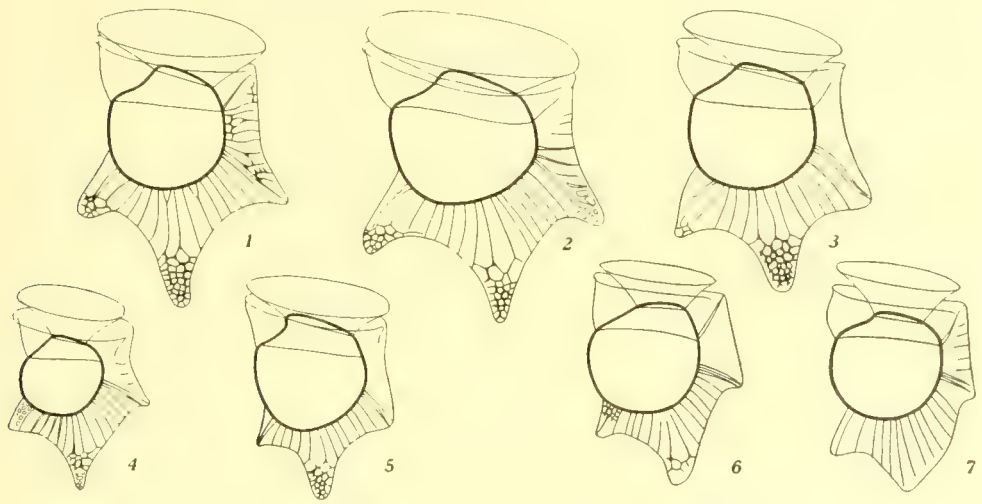

FIGURE 89.— *Ornithocercus carolinae* Kofoid, right lateral view. illustrating variations in size and in shape and structure of the left sulcal list. × 340. 1, 2, from Station 4740 (300–0 fathoms); 3, from Station 4719 (300–0 fathoms); 4, from Station 4691 (300–0 fathoms); 5, 7, from Station 4722 (300–0 fathoms); 6, from Station 4732 (300–0 fathoms).

nounced concavity of the margin between this lobe and the posterior one; sometimes, however, this margin may be nearly straight, in which case the posteroventral lobe is but slightly marked (Figure 89: 7). The posterodorsal and posterior lobes are reticulated in most specimens, but this reticulation may be absent (Figure 89: 5, 7). A submarginal rib may be present or absent. The bases of the radial ribs are usually free but may be connected by a fine reticulation. The fission rib is either subhorizontal or inclined posteriorly at 1°–40°. The depth and inclination of the epitheca and the shape of the hypotheca also exhibit variations.

Comparisons: — Our description and figures are based on the type material. The specimen figured by Jörgensen (1923, fig. 53) agrees so closely with the type that there can be no doubt as to the correctness of its allocation.

The systematic unity of this species is somewhat uncertain. Some of our specimens (Figure 89: 1–4), although varying in size, are quite uniform in structure and resemble the type (Kofoid, 1907a, fig. 92). Their specific unity appears

unquestionable. Others (Figure 89: 7) are very different from the type and approach in a striking manner *Histioneis francescae* Murray and Whitting (1899, pl. 32, fig. 3); in some of them the radial ribs of the left sulcal list were even connected by fine reticulation just as in the type of this last species. Our assignment of these aberrant specimens to *Ornithocercus carolinae* is due to the fact that transitional forms have been found (Figure 89: 5, 6).

Ornithocercus carolinae is characterized especially by the three lobes of the left sulcal list, the middle (posterior) one of which is the largest; and by the

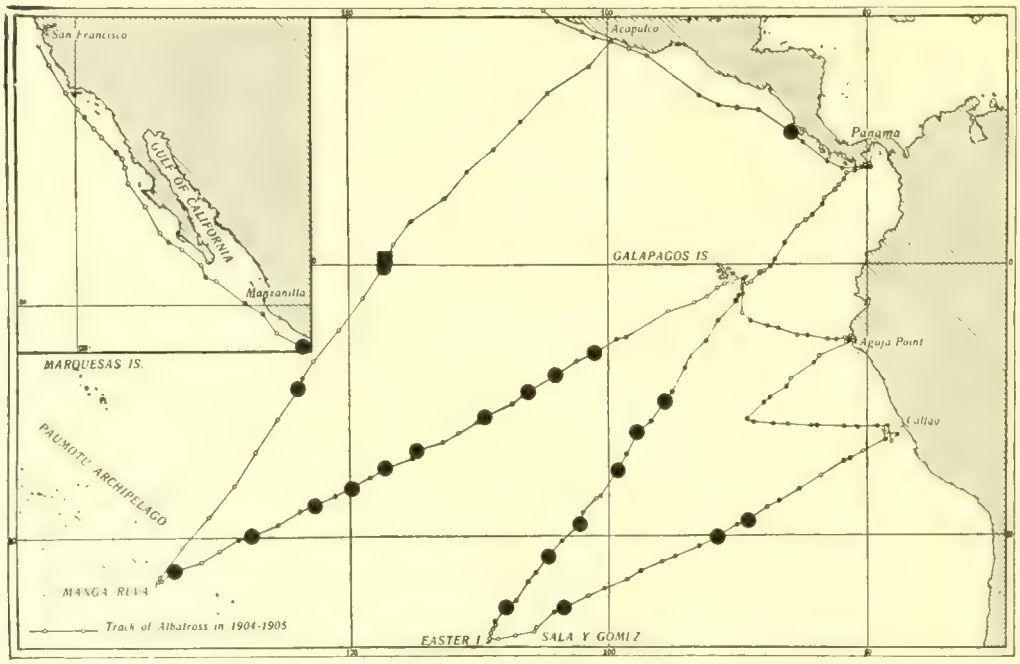

FIGURE 90.— Occurrence of *Ornithocercus carolinae* Kofoid. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

numerous radial ribs in this list behind the fission rib. Its closest-known relative is *Histioneis* [*Parahistioneis*] *francescae*, into which it even may merge (Jörgensen, 1923, p. 38). According to Murray and Whitting's (1899, pl. 32, fig. 3) figure, the type of *Histioneis francescae* differs from our atypical members of *Ornithocercus carolinae* mainly in having the entire posterior cingular list finely and evenly reticulated, while in our specimens this list is ribbed. A reinvestigation of the relationship between these two species is necessary. Within Ornithocercus the present species occupies a somewhat isolated position; and there is no clear indication as to which of the members of this genus is its closest relative.

Synonymy: — This species was established by Kofoid (1907a) under the

name of *Ornithocercus carolinae*, and this specific name was used also by Jörgensen (1923), who is the only investigator besides Kofoid to record this form.

Occurrence: — *Ornithocercus carolinae* is recorded at twenty-four of the 127 stations. There are 2, 0, 3, 6, 10, and 3 stations on the six lines of the Expedition. Of these twenty-four stations, one (4590) is in the Mexican Current; one (4613) is in the Panamic Area; three (4691, 4695, 4699) are in the Easter Island Eddy; seventeen (4681, 4683, 4701, 4705, 4707, 4709, 4719, 4721, 4722, 4724, 4728, 4730, 4732, 4734, 4737, 4739, 4740) are in the South Equatorial Drift; and two (4742, 4743) are in the South Equatorial Current. At one station (4743) the species was taken in a surface haul; at one station (4737) in a haul from 100–0 fathoms as well as in a haul from 300–0 fathoms; at two stations (4681, 4728) in hauls from both 800–0 fathoms and 300–0 fathoms. All the other records refer to hauls from 300–0 fathoms only.

The temperature range of these twenty-four stations at the surface was 68°–83°; the average was 76.1°. At Station 4743 the surface temperature was 78°.

The frequency is less than 1% at all stations except at Station 4737 where it is 1%.

The species was first recorded by Kofoid (1907a) from Stations 4719, 4721, 4722, 4724, and 4740 of the Expedition. The type specimen is from Station 4730 of the Expedition. Later Jörgensen (1923) reported it from the Bay of Cadiz, from a few localities in the central and eastern Mediterranean, and from the coast of Brazil.

This is a eupelagic, stenothermal, and warm-water species, widely distributed but rare in tropical, subtropical, and warm-temperate regions. Its absence from the California and Peruvian Currents, according to our data, as well as its rare occurrence in surface waters are noteworthy.

3. Formosus Group. The only member of this group, *Ornithocercus formosus*, was recorded from the material of the Expedition.

Ornithocercus formosus Kofoid and Michener

Plate 17, fig. 4, 5. Figure 91

Ornithocercus formosus Kofoid & Michener, 1911, p. 300.

Diagnosis: — Lateral outline subcircular. Cingular lists: anterior 0.53–0.62, posterior 0.48–0.53 the greatest depth of body; anterior with 14–17 complete radial ribs, of which some of the dorsals originate from a common stem, a few incomplete ribs, and basal reticulation; posterior with 12–15 complete ribs, some of

which may anastomose. Left sulcal list ends on dorsal side of body, 0.54–0.64 the greatest depth of body from posterior cingular list; with two narrowly rounded or subacute lobes, one of which is posterodorsal, the other posteroventral; width at former lobe 0.82–0.86, at latter lobe 0.75–0.90 the greatest depth of body; behind fission rib only one big rib, which ends at tip of posterodorsal lobe; with submarginal rib along postmargin and from posteroventral lobe to fission rib, and with fine reticulation in lobes and dorsally to big rib; between big rib and fission rib there are 10–12 weak, irregular, anastomosing or incomplete ribs. Length, 41.1–43.8 μ.

Eastern tropical Pacific.

Description: — This is a medium-sized species, subrotund in lateral outline, widest at or near the middle. The ratio between the length and the depth of the body is 0.99 (0.97–1.01) : 1. The longitudinal axis is deflected posterodorsally at about 15°.

The epitheca is 0.44 (0.41–0.48) as deep as the hypotheca, slightly convex or flat, highest in or near the center, and has a slight ventroposterior tilting. The transverse furrow is flat or gently convex; its dorsal width is 0.41 (0.33–0.47) the greatest depth of the body; and its ventral width is 0.57 (0.50–0.67) its dorsal width. The posterior cingular list is 0.24 (0.21–0.27) the length of the body from the apex. The hypotheca may be somewhat flattened dorsally and posteroventrally; its dorsal, posterior, and ventral margins are confluent. In dorsoventral view the body is subellipsoidal, broadly rounded posteriorly, subacute anteriorly, widest in the middle, and about 1.4 times longer than wide.

The anterior cingular list is 0.58 (0.53–0.62) the greatest depth of the body and has an anterior inclination of 40°–45°; on each valve it has 14–17 simple, complete radial ribs, some of the dorsal of which originate from a common stem, a few incomplete ribs, and basal reticulation. The posterior cingular list is 0.51 (0.48–0.53) the greatest depth of the body and inclined anteriorly at 70° (65°–80°); on each valve it has 12–15 complete, subequidistant radial ribs, some of the dorsal and ventral ones of which anastomose into a reticulum. The right sulcal list has been observed in one specimen only; in this specimen, the type, it was subrectangular and reticulate, ended at the fission rib, had a maximum width about 0.12 the greatest depth of the body, and its ventral margin appeared to be attached to the left sulcal list as in Histioneis (Plate 17, fig. 5). The left sulcal list ends on the dorsal side of the body at a distance from the posterior cingular list equaling 0.59 (0.54–0.64) the greatest depth of the body and is characterized by two narrowly rounded or subacute posterior lobes, one of which is posteroventral, the

other posterodorsal. The width of this list at the anterior main rib is 0.55 (0.52–0.58), at the fission rib 0.48 (0.36–0.58), at the posteroventral lobe 0.84 (0.82–0.86), and at the posterodorsal lobe 0.84 (0.75–0.90) the greatest depth of the body. The ventral margin of this list usually is almost straight and subparallel to the midline of the body, but it may bulge out into a low and broad lobe at the fission rib. Between the posterior lobes the margin is deeply concave, the minimum width of the list in this region being 0.31–0.37 the greatest depth of the body. Dorsally the margin is gently convex. Between the anterior main rib and the fission rib this list is heavily reticulated. Behind the fission rib it has only one big rib, which ends at the tip of the posterodorsal lobe. A feeble submarginal rib extends along the posterior margin, between the tips of the posterior lobes, and along the ventral margin, from the tip of the posteroventral lobe to the fission rib. Both lobes as well as the portion of the list dorsally to the big rib are finely and heavily reticulated; and between the big rib and the fission rib there are about 10–12 weak, irregular radial ribs, most of which anastomose.

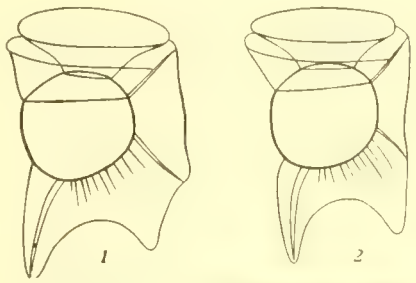

FIGURE 91. — *Ornithocercus formosus* Kofoid and Michener, right lateral view. × 340. 1, from Station 4722 (300–0 fathoms); 2, from Station 4737 (100–0 fathoms).

The thecal wall of the hypotheca is reticulate; the meshes are rounded or subangular, subuniform, of medium size, and each of them has a pore in the middle. Near the middle of the body there are about 20–25 meshes across the face of each valve. The meshes bordering the girdle posteriorly are not different in size from the others. The transverse furrow is porulate but lacks reticulation. Phaeosomes have not been observed.

The dimensions of three specimens were measured.

Dimensions: — Length of body, 41.1–43.8 μ (average, 42.9 μ; type, 41.1 μ). Greatest depth of body, 40.6–45.2 μ (average, 42.9 μ; type, 40.6 μ).

Variations: — The five specimens of this species examined as yet, were remarkably constant in size, shape, and structure. The most striking variation was found in the shape of the ventral margin of the left sulcal list. Usually this margin is almost straight, but in one specimen (Figure 91: 1) it bulged out into a low and broad lobe at the fission rib.

Comparisons: — The description and figures given in the present paper are based on the type material.

This species occupies a rather isolated position and is in several respects inter-

mediate between Ornithocercus and Histioneis. The shape and structure of its body, the size and shape of its cingular lists, the structure of its posterior cingular list, and the ending of its left sulcal list on the dorsal side of the body are characteristics typical of Ornithocercus. It resembles Histioneis in the following respects: — (*1*) the dorsal radial ribs of the anterior cingular list originate from a common stem; (*2*) the ventral margin of the right sulcal list appears to be attached to the face of the left sulcal list; (*3*) there is only one strong and complete radial rib in the left sulcal list behind the fission rib, and this strong rib runs somewhat inside the dorsal margin of this list. We do not know which of the described members of Ornithocercus is the closest-known relative of this species (see also *Histioneis costata*, the section on comparisons).

Occurrence: — *Ornithocercus formosus* is recorded at five of the 127 stations. There are 0, 0, 0, 2, 3, and 0 stations on the six lines of the Expedition. Of these five stations, one (4697) is in the Easter Island Eddy, and four (4701, 4722, 4724, 4737) are in the South Equatorial Drift. At one station (4737) the species was taken in a haul from 100–0 fathoms; the remaining records refer to hauls from 300–0 fathoms.

The temperature range of these five stations at the surface was 72.0°–81.5°; the average was 76.5°.

The frequency is in all cases less than 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4697 of the Expedition, which thus is the type locality. Its absence from the coastal currents and from the surface waters is noteworthy.

Specimens of Ornithocercus of Questionable Specific Allocation

A few of the specimens of this genus found in the material of the Expedition are of questionable specific allocation (Figure 92). These specimens appear to be abnormal, and their aberrant structure is probably, at least in most cases, due to irregularities in the regenerative processes following local injuries or to disturbances in regulatory adaptations to flotation. Instead of assigning them more or less arbitrarily to one or the other of the known species, or establishing them as types of new species, we have deemed it most advisable to treat them separately and to restrict ourselves to pointing out in which respects they approach certain known species. Future investigators may be able to solve the question of the specific allocation in a more definite manner by the application of experimental methods to form-regulation.

Figure 92: 1. This specimen resembles *Ornithocercus thurni,* but it differs from that species in having two antapical ribs in the left sulcal list, each ending in a separate (antapical) lobe. This list thus has four lobes instead of three.

Figure 92: 2. The squarish shape of the left sulcal list is suggestive of *Ornithocercus quadratus.* On the other hand, the ribs of this list behind the fission rib form an irregular reticulum and show no resemblance to those of this species.

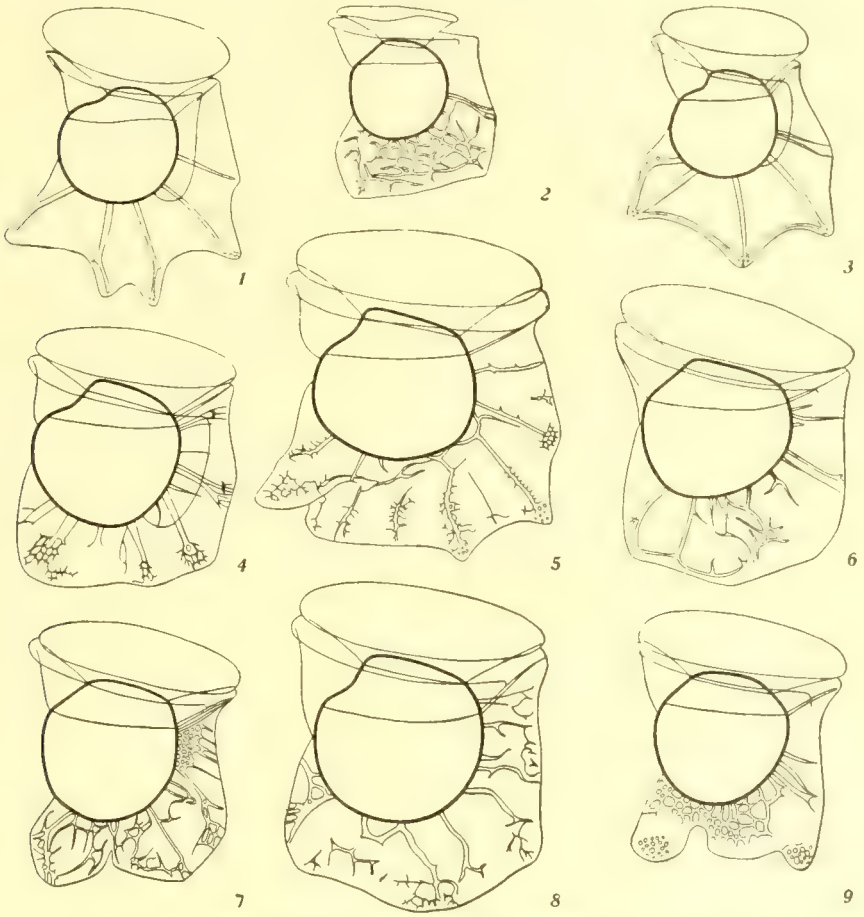

FIGURE 92.— *Ornithocercus* spp. Specimens of questionable specific allocation, right lateral view. × 340. 1, from Station 4691 (300–0 fathoms); 2, 7, from Station 4638 (300–0 fathoms); 3, from Station 4732 (300–0 fathoms); 4, from Station 4619 (surface); 5, from Station 4722 (300–0 fathoms); 6, from Station 4742 (300–0 fathoms); 8, from Station 4637 (300–0 fathoms); 9, from Station 4605 (300–0 fathoms).

Figure 92: 3. The *a*- and *b*-ribs of the left sulcal list are of about the same type as in *Ornithocercus steini,* but in other respects this specimen resembles some of our representatives of *O. thurni.*

Figure 92: 4. The squarish shape of the left sulcal list reminds us of *Ornithocercus quadratus,* but the radial ribs of this list, although quite irregular and partly incomplete, indicate relationship to *O. steini.*

Figure 92: 5. The shape of the posteroventral portion of the left sulcal list, as well as the *a*-rib of this list indicate that this is a specimen of *Ornithocercus steini*, but the irregularities in the shape of the posterodorsal portion of this list and in its *b*- and *c*-ribs prevent a definite specific allocation.

Figure 92: 6. Judging by the shape of the left sulcal list and by the *a*- and *b*-ribs of this list, this specimen belongs to *Ornithocercus thurni*. The *c*-, *d*-, and *e*-ribs of this list, however, are too irregular and incomplete to permit the assignment of this specimen to this or to any other known species.

Figure 92: 7, 9. We must refrain from attempting any specific assignment of these two specimens on account of the pronounced irregularities in the shape and structure of the left sulcal list.

Figure 92: 8. This specimen probably belongs to either *Ornithocercus steini* or *O. thurni*, but the radial ribs of the left sulcal list are too irregular and incomplete to permit even a tentative choice between these two species. The shape of this list suggests relationship to *O. thurni*.

The rounding-off of the angles of the left sulcal list and the irregularities in the ribs seen in *O. orbiculatus* are suggested in the individuals shown in Figure 92: 4, 6, and 8.

Another group of specimens cannot be determined specifically, either on account of the fact that they are not sufficiently differentiated following fission (Figure 85: 7), or due to the profound structural changes attending fission (Plate 18, fig. 2, 7–10).

Parahistioneis, gen. nov.

Plate 19, 29. Figure 93: 2–7, 85: 6

Histioneis Auctorum *partim.*

Diagnosis: — Body subrotund, subobovate, rounded squarish, carafe- or gourd-like in lateral outline, usually slightly longer than deep (ratio between length and depth, 0.86–1.44: 1), and more or less compressed bilaterally. Epitheca small, nearly flat to rather strongly vaulted; its depth 0.14–0.48 the depth of hypotheca. Transverse furrow wide, and, as a rule, decidedly wider dorsally than ventrally; dorsal width 0.37–0.63 the depth of body. Cingular lists large; anterior funnel-shaped but usually not stalked, with 1–14 complete radial ribs and a dorsal height 0.30–0.72 the depth of body; posterior usually forms a closed, cylindrical, upright collar, with less than six radial ribs and without a submarginal cross-rib, and with a dorsal height of 0.34–0.57 the depth of body. Right sulcal list small; its ventral margin probably in most species attached to the left (excep-

tion, *Parahistioneis rotundata*). Left sulcal list usually large; with but one posterior lobe and one complete radial rib behind the fission rib (exception, *P. francescae*, which has two posterior lobes and several complete radial ribs behind the fission rib); its greatest width 0.27–0.97 the depth of body.

TYPE.— *Parahistioneis diomedeae.*

Organology: — The *body* (*theca*) of Parahistioneis, when seen laterally, is always more or less asymmetrical, due especially to the shape of the transverse furrow; the hypotheca usually is subsymmetrical. In dorsoventral view, on the other hand, it appears always to be symmetrical. The longitudinal axis is perpendicular or nearly so, except in *Parahistioneis francescae* and *P. crateriformis* (Murray and Whitting, 1899, pl. 32, fig. 3; Stein, 1883, pl. 22, fig. 5, 6), in which it has a posterodorsal inclination of about 15°. The ratio between the length and the depth ranges from 0.86: 1 to 1.44: 1; usually it is somewhere between 1.08: 1 and 1.15: 1; in only one species does the depth exceed the length. In other words, the body is usually slightly longer than deep. The shape of the body in lateral view ranges from subrotund (*P. rotundata*, Figure 93: 3), subovate (*P. garretti*, Figure 93: 5), and rounded squarish (*P. paraformis*, Figure 93: 4) to carafe- (*P. karsteni*, Figure 93: 2) and gourd-like (*P. diomedeae*, Figure 93: 6). The outline in dorsoventral view is unknown in most species. When known, it sometimes is subrotund (*P. rotundata*, Plate **19**, fig. 9) or urn-shaped, widest at the posterior cingular list, well and evenly rounded posteriorly, and constricted anteriorly (*P. paraformis*, Plate **19**, fig. 6); or it is widest and strongly convex in the middle, gently concave anteriorly and posteriorly, and its apices are narrowly rounded (*P. diomedeae*, Plate **19**, fig. 4). The ratio between the length and the width ranges from 1.10: 1 to 1.58: 1.

The *epitheca* is small, and nearly flat to rather strongly vaulted. Sometimes (*Parahistioneis reticulata*, Figure 93: 7) its curvature is subsymmetrical, sometimes (*P. diomedeae*, Figure 93: 6) it is more curved dorsally than ventrally. Its depth ranges from 0.14 to 0.48 the greatest depth of the hypotheca (*P. crateriformis*, Stein, 1883, pl. 22, fig. 5, 6; *P. francescae*, Murray and Whitting, 1899, pl. 32, fig. 3). In some species (*e.g.*, *P. reticulata*, Figure 93: 7) it is subhorizontal; in others it is more or less inclined ventroposteriorly, its maximum inclination being about 20° (*P. diomedeae*, Figure 93: 6).

Due to the small size of the epitheca, the *transverse furrow* is always situated near the anterior end of the body. Its distal portion is not displaced posteriorly; in other words, it does not form a spiral about the body. Its postmargin sometimes is straight (*Parahistioneis rotundata*, Figure 93: 3), sometimes concave an-

teriorly (*P. karsteni*, Figure 93: 2), and sometimes more or less undulating (*P. diomedeae*, Figure 93: 6). It is always very wide; its dorsal width (measured in a straight line between the dorsal points of the epitheca and the hypotheca) ranges from 0.37 to 0.63 the greatest depth of the body (*P. para*, Murray and Whitting, 1899, pl. 32, fig. 4a; *P. crateriformis*, Stein, 1883, pl. 22, fig. 5, 6); and the typical range is from 0.43 to 0.54. In *P. paraformis* (Figure 93: 4) the dorsal and ventral widths are subequal, but usually the dorsal is somewhere between 1.3 and 2.5 times wider than the ventral (measured along the curvatures). Dorsally it has a dorsoposterior inclination of somewhere between 20° and 55° and is either gently convex (*P. francescae*, Murray and Whitting, 1899, pl. 32, fig. 3), or gently, moderately, to strongly concave (*P. garretti*, *P. karsteni*, *P. diomedeae;* Figure 93: 5, 2, 6). Ventrally it is gently convex, flat, or gently concave. Just as in Histioneis, the concavity and great width of this furrow are correlated with the tendency to increase the size of the girdle. This increase has two purposes: it decreases the specific weight of the organism and increases the capacity of the girdle as a container of the phaeosomes. The distance from the apex to the posterior cingular list is somewhere between 0.23 and 0.50 the length of the body.

The length of the *longitudinal furrow* usually is subequal to or somewhat less than half the length of the hypotheca. Anteriorly this list does not extend beyond the girdle and it is at most but slightly impressed.

The *lists of the furrows* are large but delicate and arise from low and narrow basal ridges (Plate 19).

The *anterior cingular list* is closed, funnel-shaped, and never notched ventrally. On the dorsal side its anterior inclination ranges from 15° to 60° (usually between 20° and 40°); on the ventral side this inclination either is subequal to that of the dorsal side, or it is somewhat steeper (*Parahistioneis reticulata* and *P. karsteni;* Figure 93: 7, 2). In most species (*e.g.*, *P. diomedeae*, Figure 93: 6) this list is sessile; in others (*P. karsteni* and *P. rotundata;* Figure 93: 2, 3) it either has an incipient or a short stalk. It always is characterized by a distal flare, which either is symmetrical (*P. paraformis*, Figure 93: 4) or more pronounced dorsally than ventrally (*P. rotundata*, Figure 93: 3). Distally this list is from two to six times wider than proximally. Its dorsal height ranges from 0.30 to 0.72 (usually from 0.50 to 0.65) the greatest depth of the body; and its right and left sides are of about equal height. Its anterior margin is even, except in *P. dentata* (Murray and Whitting, 1899, pl. 33, fig. 4), in which it is deeply serrated, the teeth, according to the figure, being scale-like and overlapping. When sessile, this list has a

fairly great number of radial ribs (about eight to fourteen), most of which are complete, and all of which are simple except the dorsal which has one to many branches (Plate **19**, fig. 1, 10, 4). When stalked, it is characterized by a more or less reduced number of well-developed radial ribs, the dorsal of which are branched (*P. karsteni* and *P. rotundata;* Plate **19**, fig. 2, 8). Besides the complete ribs, this list may have some incomplete, simple, marginal, radial ribs (*P. diomedeae*, Plate **19**, fig. 5) and a basal reticulation (*P. garretti* and *P. paraformis;* Plate **19**, fig. 1, 3). The tips of the ribs may project slightly beyond the free edge of the list.

The *posterior cingular list* is closed except posteroventrally, where it probably opens into the canal formed by the right sulcal list. *Parahistioneis rotundata* (Plate **19**, fig. 8) is presumably an exception to this rule; in this species this list appears to be open ventrally. (This character is not known in *P. francescae.*) In most species this list forms a cylindrical, upright collar of moderate height and about as high dorsally as ventrally; sometimes, however, its anterior inclination does not amount to more than about 65° (*P. paraformis* and *P. garretti;* Figure 93: 4, 5). It may flare anteriorly (*P. reticulata* and *P. diomedeae;* Plate **19**, fig. 7, 10, 4), but it never forms lateral pouches. Its dorsal height ranges from 0.34 to 0.57 the greatest depth of the body. The structural differentiation of this list usually is very simple. In some species (*P. crateriformis*, Stein, 1883, pl. 22, fig. 5, 6) this list has only a pair of simple, dorsal ribs, one rib on either side of the sagittal suture, and a similar pair ventrally; others (*P. paraformis* and *P. rotundata;* Plate **19**, fig. 3, 8) have besides the sagittal ribs only one to four simple, radial ribs and sometimes a slight reticulation dorsally and ventrally; others, again, have no radial ribs except the sagittal ribs, but a more or less developed, fine reticulation (*P. diomedeae* and *P. reticulata;* Plate **19**, fig. 5, 7). The number of radial ribs in this list is thus always small. In contradistinction to Histioneis, a submarginal cross-rib is never present, but in one species (*P. dentata*, Murray and Whitting, 1899, pl. 33, fig. 4) the anterior margin is thickened.

In *Parahistioneis rotundata* (Plate **19**, fig. 8) the *right sulcal list* is fairly large and ends at the fission rib of the left sulcal list; its ventral margin is sigmoid and probably free, and it lacks structural differentiation. On the other hand, in *P. diomedeae* and *P. dentata* (Plate **19**, fig. 5; Murray and Whitting, 1899, pl. 33, fig. 4a) this list is relatively very small, finely reticulated, and its ventral margin is attached to the left sulcal list, thus forming a canal, which opens posteriorly near the fission rib of the left sulcal list and presumably also into the girdle. Just as in Histioneis, the water caused by the movement of the transverse flagellum to enter the girdle probably passes out by this canal. The condition of this list

in the last two species may be similar to that of the remaining members of this genus, in which this structure is unknown. This assumption is made probable by the fact that in these species the posterior cingular list is closed; furthermore, the small size and the attachment of the ventral margin make this list very difficult to detect, which would explain why it has not been recorded.

The *left sulcal list* usually is rather large. In some species (*Parahistioneis paraformis* and *P. reticulata;* Figure 93: 4, 7) it ends at or just ventrally to the antapex of the body; in others it extends more or less beyond this point and may end on the dorsal side of the body at a distance from the posterior cingular list equaling only about 0.47 the greatest depth of the body (*P. diomedeae,* Figure 93: 6). The shape and structure of this list are quite diverse within this genus and afford important taxonomic characteristics. The most aberrant type is found in *P. francescae* (Murray and Whitting, 1899, pl. 32, fig. 3). In this species this list ends on the dorsal side of the body, at a distance from the posterior cingular list equaling about 0.55 the greatest depth of the body, and is characterized by two well-developed lobes, one of which is posterodorsal, the other antapical. At the latter lobe, which is by far the larger, the list reaches its greatest width, viz., about 0.67 the greatest depth of the body. The ventral margin (to the tip of the antapical lobe) is moderately convex; and the margin between the vertices of the lobes is rather strongly concave, subrectangular. The fission rib, which arises a fairly short distance behind the girdle, is about 0.43 the greatest depth of the body, nearly straight, and slightly deflected posteriorly. A strong rib, the posterior main rib, ends in the posterodorsal lobe. Dorsally to the latter rib and anteriorly to the fission rib, this list is reticulate. Between these ribs there are fifteen weak radial ribs partly connected by reticulations and with their tips joined by a submarginal rib. This is the only species of this genus in which this list has two posterior lobes and more than one complete radial rib behind the fission rib. In the remaining ones this list has one posterior lobe and two complete radial ribs, viz., the fission rib and the posterior main rib, and it is always widest at the tip of the posterior lobe. The fission rib, which arises at or near the posterior end of the longitudinal furrow, is double, straight or nearly so, and subhorizontal (*P. rotundata,* Figure 93: 3) or deflected posteriorly at 1°–45°; its length ranges from 0.12 to 0.35 the greatest depth of the body. The posterior main rib, which arises at or somewhat ventrally to the antapex of the body and ends at or near the vertex of the posterior lobe, either is marginal (*P. para,* Figure 85: 6) or it arises at some distance from the dorsal end of the list; this distance may be as long as 0.54 the greatest depth of the body (*P. diomedeae,* Figure 93: 6). This rib is di-

rected posteriorly or deflected ventrally at 1°–30° from the longitudinal axis of the body, and its length ranges from 0.27 to 0.97 the greatest depth of the body; it may be of moderate strength or strong; usually it is simple and tapers distally, but its distal end may be reticulate or club-shaped (*P. paraformis* and *P. diomedeae;* Figure 93: 4, 6); and it is straight, gently concave dorsally, or gently sigmoid. In one species (*P. diomedeae,* Figure 93: 6) the ventral margin of this list forms a rounded rectangular lobe at the fission rib; in the others this margin (from the anterior edge of the posterior cingular list to the tip of the posterior lobe) does not form any distinct lobe but is gently to moderately convex (*P. paraformis,* Figure 93: 4; *P. crateriformis,* Stein, 1883, pl. 22, fig. 5, 6), moderately to strongly sigmoid (*P. rotundata,* Figure 93: 3; *P. dentata,* Murray and Whitting, 1899, pl. 33, fig. 4a), or strongly undulating (*P. karsteni,* Figure 93: 2). At the tip of the posterior main rib the margin is narrowly rounded or acute, and dorsally to this rib it is gently concave, straight, gently convex, or gently to strongly sigmoid. In front of the fission rib this list usually is reticulate, but it may have but a few short radial marginal ribs (*P. rotundata,* Figure 93: 3) or be without structural differentiation (*P. crateriformis,* Stein, 1883, pl. 22, fig. 5, 6). Between the two main ribs it may be entirely or partly reticulate (*P. reticulata* and *P. garretti;* Plate **19**, fig. 7, 1), or it may have a few short radial basal ribs (*P. crateriformis,* Stein, 1883, pl. 22, fig. 5) or a submarginal rib as well as short radial basal ribs (*P. rotundata,* Figure 93: 3). Dorsally to the posterior main rib this list may be reticulate or it may lack structural differentiation.

Parasagittal lists have thus far not been found in this genus.

The *flagellar pore,* which is located to the right in the transverse furrow at or just behind the posterior cingular list, is rounded or slightly elongated and has a maximum diameter of about 4 μ. There are no records of pores of the kind found in Phalacroma (Plate **3**, fig. 1, 2, of *P. pulchrum* and *P. giganteum*) on the ventral side of the left valve, near the sagittal suture, and just in front of the anterior cingular list. The *flagella,* which have not been observed as yet, presumably are similar to those in Dinophysis and Phalacroma.

The *thecal wall* exhibits but slight variations in structure. It is always porulate, and in all species, except *Parahistioneis rotundata,* it is strongly areolate or reticulate. There is either one pore in each mesh and areole, or there is a smaller number of pores than areoles and meshes. In *P. rotundata* (Plate **19**, fig. 8) the wall of the hypotheca is finely and very faintly reticulate and has but eleven pores on the right face, six of which are located along the girdle.

The *protoplasmic contents* have thus far not been observed. Large, rounded

and small, ovoidal *phaeosomes* have been found in the girdle (Plate **19**, fig. 5, 7).

The *length of the body* ranges within this genus from 17.7 μ (*Parahistioneis rotundata*) to 53.5 μ (*P. diomedeae*).

The methods of measurement are largely the same as in Histioneis.

Distribution: — Parahistioneis belongs to the same distributional group as Histioneis; in other words, it is marine, presumably of circumequatorial distribution, avoids coastal waters, is limited to tropical and subtropical seas, and all its species are very rare. In the Atlantic as well as in the Pacific Ocean its northern limit seems to be near lat. 35° N.; its southern extension is unknown. It has not been found as yet in the Mediterranean. The distribution of the genus as a whole and of the individual species is very uncertain due to the scarcity of distributional data.

The vertical distribution of this genus must be regarded as unknown. All the records published as yet are from surface hauls.

Representatives of Parahistioneis were found at sixteen (12.6%) out of the 127 stations of the Expedition from which dinoflagellates were recorded. These sixteen stations were distributed in the following manner (Plate **29**):—

0 (0.0%) out of the four stations in the California Current; 2 (15.4%) out of the thirteen stations in the Mexican Current; 1 (5.9%) out of the seventeen stations in the Panamic Area; 0 (0.0%) out of the twenty-seven stations in the Peruvian Current; 2 (20.0%) out of the ten stations in the Easter Island Eddy; 0 (0.0%) out of the four stations in the Galapagos Eddy; 11 (24.4%) out of the forty-five stations in the South Equatorial Drift; 0 (0.0%) out of the three stations in the South Equatorial Current; 0 (0.0%) out of the two stations in the Equatorial Counter Current; 0 (0.0%) out of the two stations in the North Equatorial Current.

The numbers of these sixteen stations are as follows: — 4598, 4604 (Mexican Current); 4619 (Panamic Area); 4697, 4699 (Easter Island Eddy); 4701, 4709, 4711, 4720, 4722, 4724, 4725, 4732, 4733, 4734, 4741 (South Equatorial Drift).

At nine out of these sixteen stations the genus was taken in hauls from 300–0 fathoms or from 800–0 fathoms. One (4598) of these nine stations is located in the Mexican Current; two (4697, 4699) are in the Easter Island Eddy; and six (4701, 4711, 4722, 4724, 4732, 4734) in the South Equatorial Drift. At seven stations the genus was found in surface waters. These stations are as follows: — 4604 (Mexican Current); 4619 (Panamic Area); 4709, 4720, 4725, 4733, 4741 (South Equatorial Drift).

These data show that Parahistioneis was not found by the Expedition in the California and Peruvian Currents, both of which are of temperate origin, in the Galapagos Eddy, which is directly influenced by the Peruvian Current, or in the South Equatorial Current, Equatorial Counter Current, and the North Equatorial Current. Most (eleven out of sixteen) of the record stations are in the South Equatorial Drift. The species of this genus evidently are stenothermal, warm-water forms limited to high salinities.

There are seventeen records of species of Parahistioneis from vertical catches. Out of these seventeen records, three (17.7%; Stations 4598, 4699, 4722) showed a frequency of 1%; the remaining fourteen (82.3%) showed a frequency of less than 1%. There are eleven records of species from surface catches. Out of these eleven records, one (9.1%; Station 4619) showed a frequency of 2%; one (9.1%; Station 4720) showed 1%; the remaining nine (81.8%) showed less than 1% or did not have the frequency established. The average frequency of the individual species is about as low as in the genus Histioneis.

Coincident occurrence of different species of Parahistioneis in catches from 300 (800)–0 fathoms is recorded at the following of the nine stations mentioned above: — three species occurred coincidently at one station (11.1%; Station 4699); two species at six stations (66.7%; Stations 4697, 4701, 4722, 4724, 4732, 4734). Coincident occurrence of different species of this genus in surface catches is recorded at the following of the seven stations mentioned above: — three species occurred coincidently at one station (14.3%; Station 4733); two species at two stations (28.6%; Stations 4619, 4720).

It should be mentioned that during the Expedition only two, *Parahistioneis diomedeae* and *P. reticulata*, out of the six species were found free-living in surface waters. The remaining surface records refer to specimens found in the stomachs of Salpa taken near the surface. The following species were found in Salpa stomachs: — *P. diomedeae*, *P. karsteni*, *P. paraformis*, *P. reticulata*, and *P. rotundata*.

Out of our seven species only two have been found outside the area investigated by the Expedition, a fact undoubtedly due to the incompleteness of our knowledge of the distribution of this genus.

Historical Discussion

Of the nine species referred by us to the genus Parahistioneis, one, *P. paraformis*, is proposed in the present paper, and the remaining ones were previously described and figured in the genus Histioneis. These species are as follows: —

Histioneis crateriformis Stein (1883), *H. dentata* Murray and Whitting (1899), *H. diomedeae* Kofoid and Michener (1911), *H. francescae* Murray and Whitting (1899), *H. garretti* Kofoid (1907a), *H. karsteni* Kofoid and Michener (1911), *H. para* Murray and Whitting (1899), *H. reticulata* Kofoid (1907a), and *H. rotundata* Kofoid and Michener (1911).

The following investigators have contributed to our knowledge of the distribution of this genus, not specifying those mentioned above: — Cleve (1901a, 1901c), Daday (1888), Lemmermann (1899a, 1901a), Lohmann (1908), Ostenfeld and Schmidt (1901), and Schröder (1900a). None of these writers gives figures by means of which the determinations may be checked. Minor contributions are found in Bütschli (1885) and Jörgensen (1923). The cytological aspect of the morphology of this genus has not been treated as yet.

Subdivisions. Relationships among the Species

The ten species referred to Parahistioneis in the present paper may be divided as follows:

1. Species of uncertain generic allocation: — *P. francescae*, *P. crateriformis*, and *P. rotundata* (Figure 93: 3; Murray and Whitting, 1899, pl. 32, fig. 3; Stein, 1883, pl. 22, fig. 5, 6).

2. Garretti group: — *P. garretti*, *P. paraformis*, and *P. para* (Figure 93: 5, 4; 85: 6).

3. Reticulata group: — *P. karsteni*, *P. reticulata*, *P. diomedeae*, and *P. dentata* (Figure 93: 2, 7, 6; Murray and Whitting, 1899, pl. 33, fig. 4).

1. Species of uncertain generic allocation. *Parahistioneis francescae* (Murray and Whitting, 1899, pl. 32, fig. 3): — The structurally closest-known relative of this species is *Ornithocercus carolinae* (Figure 89). Indeed, these two forms approach each other so closely that even their specific separation has been questioned (Jörgensen, 1923, p. 38), and our material indicates that their ranges of variation overlap. The only reason for the present (tentative) generic assignment is that the posterior cingular list of *P. francescae* is finely and evenly reticulated, instead of ribbed, according to Murray and Whitting's (1899) figure. It is possible, however, that this peculiarity of the type specimen is due to advanced ontogenetic differentiation; in other words, that the reticulation is preceded by ribbing, the ribs later being connected by numerous fine anastomoses (see *Ornithocercus carolinae*, the section on comparisons). If this is the case, then *Parahistioneis francescae* should be referred to Ornithocercus. Murray and Whitting

(1899), who did not separate Ornithocercus from Histioneis, referred it to the latter genus.

Parahistioneis crateriformis (Stein, 1883, pl. 22, fig. 5, 6): — This species is structurally fairly close to some of the primitive members of Histioneis, and the only character that prevents its assignment to this genus is the lack of a cross-rib in its posterior cingular list. If this rib is absent, in other words, if Stein (1883) did not overlook it, then this species should be assigned to the RETICULATA group and be placed near *Parahistioneis karsteni*. Stein (1883) assigned it to Histioneis.

Parahistioneis rotundata (Figure 93: 3): — This species, which was referred to Histioneis by Kofoid and Michener (1911), occupies a somewhat isolated position and embodies characteristics of Ornithocercus and Histioneis, as well as of Parahistioneis. It is characterized especially by the following features: — its body is subrotund and lacks an anterior process; its anterior cingular list is stalked and has but few (five or less) ribs on each valve; its posterior cingular list appears to be open ventrally and has about five radial ribs on each valve; its right sulcal list is comparatively large, and its ventral edge appears to be free, *i.e.*, not attached to the left sulcal list. If by future investigations it is shown: (*1*) that the posterior cingular list of this species is open ventrally, (*2*) that the ventral edge of its right sulcal list is not attached to the left sulcal list, and (*3*) that these peculiarities are not found in the GARRETTI and RETICULATA groups, then this species should be removed from Parahistioneis and made the type of a new genus. We thus regard its present generic allocation as tentative.

The three members of this group thus may be representatives of three different genera.

2. GARRETTI group (Figure 93: 5, 4; 85: 6). Body subovate to rounded squarish in lateral outline, without a well-developed anterior process. Anterior cingular list sessile, with eight or more radial ribs on each valve. Posterior cingular list appears always to be closed ventrally and has two to four radial ribs on each valve besides the dorsal and ventral pairs next to the sagittal suture. Right sulcal list small; its ventral edge attached to left sulcal list (?).

The three members of this group are structurally very uniform and have reached about the same evolutionary level.

3. RETICULATA group (Figure 93: 2, 7, 6; Murray and Whitting, 1899, pl. 33, fig. 4). Body carafe- or gourd-shaped in lateral outline with well-developed anterior process. Anterior cingular list may have an incipient stalk but is usually sessile; with five or more radial ribs on each valve. Posterior cingular list appears always to be closed ventrally and has no radial ribs except the dorsal and ventral

pairs next to the sagittal suture. Right sulcal list small; its ventral edge attached to left sulcal list (?).

Of the four species assigned to this group, *Parahistioneis reticulata*, *P. diomedeae*, and *P. dentata* are structurally very close to each other and have reached about the same evolutionary level. *P. dentata* is somewhat aberrant in having the anterior edge of the anterior cingular list deeply serrated and the anterior edge of the posterior cingular list supported by a marginal rib. (These features are unique and need to be verified.) *P. karsteni* is somewhat more primitive than these three species in being smaller and in having the anterior process of the body somewhat less developed. On the other hand, it is more advanced in having the anterior cingular list characterized by an incipient stalk and by a small number of radial ribs.

The RETICULATA group, which is quite primitive in the shape and structure of the anterior cingular list, is more advanced than the GARRETTI group in the shape of the body and in the structure of the posterior cingular list; the body has developed a large anterior process, and in the posterior cingular list the primitive ribbing has disappeared.

Key to the Species of Parahistioneis

1. Posterior cingular list with no radial ribs besides the dorsal and ventral pairs.....2.
1. Posterior cingular list with radial ribs besides the dorsal and ventral pairs.....7.
2. Left sulcal list with two distinct posterior lobes, one of which is dorsoposterior, the other antapical; R_3 ends in dorsoposterior lobe.....*P. francescae* (Murray and Whitting).
2. Left sulcal list not of this type.....3.
3. Anterior edge of anterior cingular list deeply serrated.....*P. dentata* (Murray and Whitting).
3. Anterior edge of anterior cingular list smooth.....4.
4. Left sulcal list angular at R_2.....*P. diomedeae* (Kofoid and Michener).
4. Left sulcal list not angular at R_2.....5.
5. Left sulcal list wide; R_3 0.67 the depth of body.....*P. karsteni* (Kofoid and Michener).
5. Left sulcal list fairly narrow; R_3 less than 0.45 the depth of body.....6.
6. Anterior cingular list sessile, its dorsal height 0.32–0.40 the depth of body..*P. reticulata* (Kofoid).
6. Anterior cingular list stalked, its dorsal height 0.70–0.75 the depth of body..*P. crateriformis* (Stein).
7. R_3 of left sulcal list arises about 0.50 the depth of body from dorsal end of list..*P. garretti* (Kofoid).
7. R_3 of left sulcal list submarginal.....8.
8. R_3 of left sulcal list with heavy posterior reticulation.....*P. paraformis*, sp. nov.
8. R_3 of left sulcal list not with heavy posterior reticulation.....9.
9. Anterior cingular list stalked, with five ribs or less on each valve..*P. rotundata* (Kofoid and Michener).
9. Anterior cingular list not stalked, with ten ribs or more on each valve.
P. para (Murray and Whitting).

1. SPECIES OF UNCERTAIN GENERIC ALLOCATION. Of the three species of this group, viz., *Parahistioneis francescae*, *P. crateriformis*, and *P. rotundata*, only the last was found in the material of the Expedition.

Parahistioneis rotundata (Kofoid and Michener)

Plate 19, fig. 8, 9. Figure 93: 3

Histioneis rotundata Kofoid & Michener, 1911, p. 299.

Diagnosis: — Body subcircular in lateral outline; length: depth, 1.13: 1. Dorsally the transverse furrow is gently concave, 0.48 the depth of body, 1.3 times wider than ventrally, and inclined dorsoposteriorly at 20°. Distance from apex to posterior cingular list 0.23 the length of body. Anterior cingular list with short stalk, flaring in its distal 0.66 with straight sides to an asymmetrical funnel 1.5 wider dorsally than ventrally; its height 0.64 the depth of body. Posterior cingular list appears to be open ventrally; with five to six simple, complete ribs; dorsal height 0.39 the depth of body. Left sulcal list ends somewhat ventrally to antapex; narrowly rounded at R_3; margin rather strongly convex just behind R_2; dorsal margin gently concave; R_2 0.32 the depth of body; R_3 submarginal, of moderate strength, 0.78 the depth of body; from near the middle of R_2 a rib runs posteriorly, subparallel to margin of list; between R_2 and R_3 there are four incomplete ribs. Length, 17.7 μ.

Eastern tropical Pacific.

Description: — This is a minute species, the body of which is subcircular in lateral outline, and deepest near the middle. The ratio between the length and the depth of the body is about 1.13: 1. The longitudinal axis is perpendicular.

The epitheca is about 0.17 as deep as the hypotheca, convex, highest somewhat dorsally to the center, and subhorizontal. Dorsally the transverse furrow is gently concave, about 0.48 the greatest depth of the body, about 1.3 times wider than ventrally, and inclined dorsoposteriorly at about 20°; ventrally it is gently convex. The distance from the apex to the posterior cingular list is about 0.23 the length of the body. The anterior margin of the hypotheca is nearly straight and horizontal. The dorsal, posterior, and ventral margins are confluent and subcircular. Seen in dorsoventral view, the body is regularly and broadly obovoidal, widest near the middle, and about 1.10 times longer than wide.

The anterior cingular list has a short but distinct stalk, is inclined anteriorly at 35°–40°, and is about 5.5 times wider distally than proximally; it flares in its distal 0.66 abruptly with straight sides to an asymmetrical funnel 1.5 times wider dorsally than ventrally, inclined slightly dextrally with no ventral notch; its height is about 0.64 the greatest depth of the body; and it has on each valve two radial ribs, the ventral of which is simple, the dorsal furnished with three branches. The posterior cingular list appears to be open ventrally, and its dorsal

margin is inclined anteriorly at 80°–85°; the dorsal height is about 0.39, the ventral 0.48 the greatest depth of the body; it has on each valve five to six simple, complete radial ribs and no reticulation. The right sulcal list ends at the fission rib of the left sulcal list, and its ventral margin, which appears to be free, is strikingly sigmoid, concave in the middle, and convex posteriorly. The left sulcal list ends somewhat ventrally to the antapex, the ventral margin is nearly straight in front of the fission rib, between the fission rib and the posterior main rib the margin is rather strongly convex anteriorly and nearly straight posteriorly, at the posterior main rib the list is narrowly rounded, and the dorsal margin is gently concave. The fission rib is straight, subhorizontal, and about 0.32 the greatest depth of the body. The posterior main rib is submarginal, of moderate strength, gently concave dorsally, deflected 5°–10° posteroventrally, and about 0.78 the greatest depth of the body; on the ventral side it has about six knob-like processes. In front of the fission rib there are about four short, marginal radial ribs. From near the middle of the fission rib, a rib runs posteriorly and about parallel to the ventral margin, ending near the posterior main rib. Between the fission rib and the posterior main rib there are four incomplete basal ribs, the anterior of which is fairly long, bent posteriorly, and branched distally.

The thecal wall of the hypotheca is finely and very faintly reticulated and has eleven pores on the right face, six of which are located along the girdle. There are no records of phaeosomes.

The dimensions of one specimen only, the type, were measured.

Dimensions: — Length of body, 17.7 μ. Greatest depth of body, 15.7 μ. Total length, 37.1 μ.

Comparisons: — Our description and figures are based on the type specimen.

This species occupies a somewhat isolated position. It embodies characteristics of Ornithocercus, Histioneis, and Parahistioneis, and hence even its generic assignment should be regarded as tentative. The subcircular outline of the body in lateral view, the ribbing of the posterior cingular list, and the development of the right sulcal list indicate relationships to Ornithocercus. It differs from this genus in having comparatively few ribs in the posterior cingular list, in the shape and structure of the anterior cingular list, and in having only two main ribs in the left sulcal list. The shape and structure of the anterior cingular list remind us of Histioneis and the shape of the left sulcal list of *Parahistioneis karsteni*. There is no certain indication as to which of the known members of these three genera is the closest relative of the present species. The minute size, the subspheroidal

shape of the body, the size of the right sulcal list, and the fact that the left sulcal list ends on the ventral side of the body, place it fairly low in the evolutionary scale.

Occurrence: — *Parahistioneis rotundata* is recorded at five of the 127 stations. One station (4709) is on the fourth, three (4720, 4725, 4733) are on the fifth, and one (4741) is on the sixth line of the Expedition, and all of them are in the South Equatorial Drift. Five specimens were found, all occurring in Salpa taken in

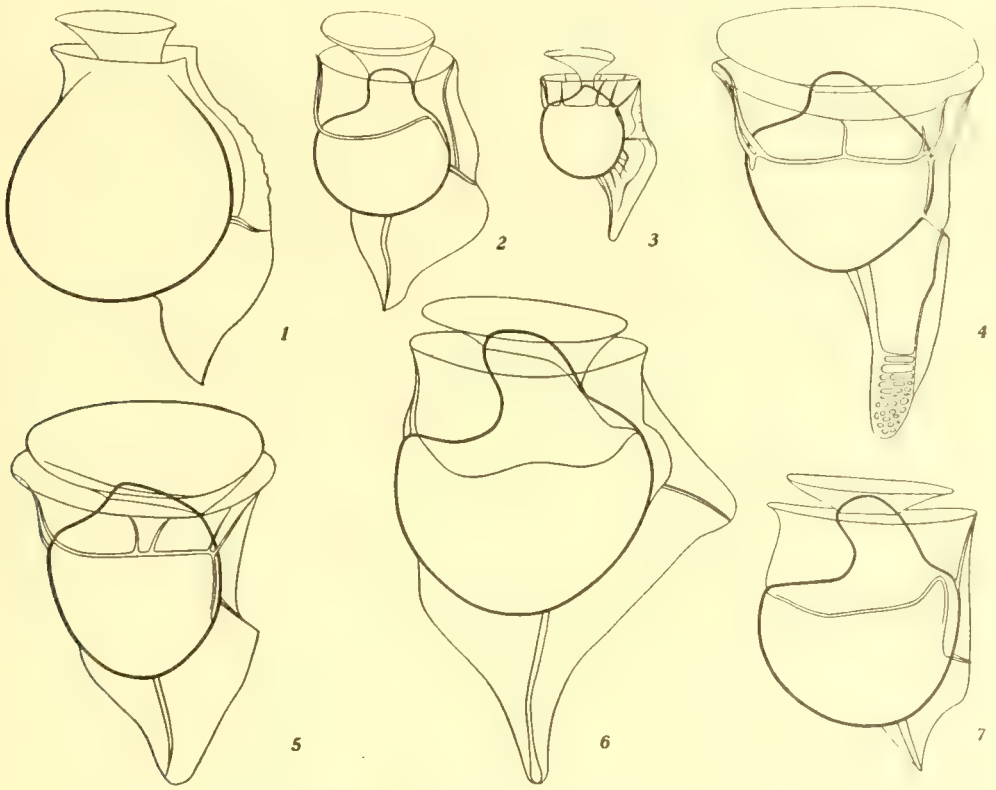

FIGURE 93.— Histiophysis and Parahistioneis, right lateral view. × 340. 1, *Histiophysis rugosa* (Kofoid) from Station 4705 (300–0 fathoms); 2, *Parahistioneis karsteni* (Kofoid and Michener) from Station 4619 (Salpa); 3, *P. rotundata* (Kofoid and Michener) from Station 4720 (Salpa); 4, *P. paraformis*, sp. nov., from Station 4724 (300–0 fathoms); 5, *P. garretti* (Kofoid) from Station 4732 (300–0 fathoms); 6, *P. diomedeae* (Kofoid and Michener) from Station 4699 (300–0 fathoms); 7, *P. reticulata* (Kofoid) from Station 4699 (300–0 fathoms).

surface waters. The temperature of these five stations at the surface ranged from 72° to 80°; the average was 77.0°.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4720 of the Expedition, which thus is the type locality. The restriction of all the record stations to the South Equatorial Drift is noteworthy.

2. Garretti Group. All the three members of this group were found by us in the material of the Expedition. They have been treated in the following order: — *Parahistioneis garretti*, *P. paraformis*, and *P. para*.

Parahistioneis garretti (Kofoid)

Plate 19, fig. 1. Figure 93: 5

Histioneis garretti Kofoid, 1907a, p. 203, pl. 16, fig. 97.

Diagnosis: — Body broadly subobovoidal in lateral outline; length: depth, 1.15: 1. Dorsally the transverse furrow is gently concave, 0.52 the depth of body, 2.3 times wider than ventrally, and inclined dorsoposteriorly at 35°–40°. Distance from apex to posterior cingular list 0.36 the length of body. Anterior cingular list sessile, subequal dorsally and ventrally; its height 0.60 the depth of body. Posterior cingular list closed; with two simple ribs in the middle and one ventrally; dorsal height 0.52 the depth of body. Left sulcal list ends on dorsal side of body, 0.59 the depth of body from posterior cingular list; narrowly rounded at R_3; dorsal margin and margin between R_2 and R_3 gently sigmoid; R_2 0.31 the depth of body; R_3 arises 0.50 the depth of body from dorsal end of list, fairly weak, 0.60 the depth of body; reticulated in front of R_2; behind R_2 reticulations are restricted to basal portion. Length, 37.3 μ.

Eastern tropical Pacific.

Description: — This is a medium-sized species, with body broadly subobovoidal in lateral outline, deepest just behind the transverse furrow. The ratio between the length and the depth of the body is about 1.15: 1. The longitudinal axis is about perpendicular.

The epitheca is about 0.55 as deep as the hypotheca, convex, highest dorsally, and tilted ventroposteriorly at about 10°. Dorsally the transverse furrow is gently concave, about 0.52 the greatest depth of the body, about 2.3 times wider than ventrally, and inclined dorsoposteriorly at 35°–40°; ventrally it is gently convex. The distance from the apex to the posterior cingular list is about 0.36 the length of the body. The anterior margin of the hypotheca is nearly straight and subhorizontal. The dorsal, posterior, and ventral margins are confluent; the posterior is somewhat more convex than the others.

The anterior cingular list is sessile, inclined at the base anteriorly at 15°–25°, and about 2.5 times wider distally than proximally; it flares into a broad funnel with nearly equal dorsal and ventral extent, straight sides, and with the ventral arising farther posterior than the dorsal and therefore steeper. Its top, somewhat flattened in Figure 93: 5, is nearly horizontal, its height is about 0.60 the greatest

depth of the body, and it has on each valve 11 or 12 subequidistant radial ribs, most of which are complete, and all of which are simple except the dorsal one, which has two branches; proximally these ribs are connected by reticulation. The posterior cingular list is closed, somewhat flaring distally, and its dorsal and ventral margins are inclined anteriorly at 50°–70°; the dorsal height is about 0.52, the ventral 0.57 the greatest depth of the body; besides the ribs at the sagittal suture, this list has on each valve three simple, straight radial ribs, two of which are near the middle and one ventrally; dorsally a slight reticulation is present. The left sulcal list is of medium size and ends on the dorsal side of the body at a distance from the posterior cingular list equaling about 0.59 the greatest depth of the body. It is narrowly rounded at the posterior main rib; and the dorsal margin and the margin between the fission rib and the posterior main rib are gently sigmoid. The portion of this list in front of the fission rib is finely reticulated; in the type specimen it is but slightly developed (following fission?), its ventral margin is gently concave, and its posterior width is but slightly more than half the length of the fission rib. The fission rib is straight, about 0.31 the greatest depth of the body, and deflected posteriorly at about 25°. The posterior main rib arises near the antapex of the body and about 0.50 the greatest depth of the body from the dorsal end of the list, is fairly weak, gently concave dorsally, and deflected posteroventrally at 5°–10°; its length is about 0.60 the greatest depth of the body. Behind the fission rib the basal portion of this list is reticulated, the meshes being rather small to medium-sized.

The thecal wall is porulate and reticulated, the meshes being subuniform and medium-sized, and each of them having one pore in the middle. On each valve about eighteen meshes border the girdle posteriorly. There is no record of phaeosomes.

The dimensions of one specimen only, the type, were measured.

Dimensions: — Length of body, 37.3 μ. Greatest depth of body, 32.3 μ. Total length, 72.5 μ.

Comparisons: — Our description and figure are based on the type specimen.

Judging by the size, shape, and structure of the body, of the cingular lists, and of the left sulcal list in front of the fission rib, this species is most closely related to *Parahistioneis paraformis*. These two species are readily distinguished from each other by the shape and structure of the left sulcal list behind the fission rib. Another close relative evidently is *P. para*. This relationship is indicated by pronounced similarities in the shape and structure of the body and of the cingular lists. *P. garretti* differs strikingly from *P. para* in having the left

sulcal list end on the dorsal side of the body and in having the posterior main rib of this list arise at a distance from the dorsal end of the list equaling 0.50 the greatest depth of the body.

Occurrence: — *Parahistioneis garretti* is recorded at only one of the 127 stations, 4732, on the fifth line of the Expedition in the South Equatorial Drift, from a haul from 300–0 fathoms, a surface temperature of 79°. The frequency is less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4732 of the Expedition, which thus is the type locality.

Parahistioneis paraformis, sp. nov.

Plate 19, fig. 3, 6. Figure 93: 4

? *Histioneis para* Murray & Whitting, 1899, *partim*, pl. 32, fig. 4c.
Histioneis para Okamura, 1912, p. 20, pl. 3, fig. 55.

Diagnosis: — Body rounded, squarish in lateral outline; length: depth, 1.08–1.11: 1. Dorsally the transverse furrow is moderately concave, 0.48 the depth of body, but slightly wider than ventrally, and inclined dorsoposteriorly at 40°–45°. Distance from apex to posterior cingular list 0.43 the length of body. Anterior cingular list sessile, low, subequal, broadly flaring; its height 0.61 the depth of body. Posterior cingular list closed, with one simple rib in the middle and one ventrally; dorsal height 0.53 the depth of body; line of attachment subhorizontal. Left sulcal list ends at antapex; narrowly rounded posteriorly, gently convex between R_2 and R_3, gently concave dorsally; R_2 0.35 the depth of body; R_3 submarginal, strong, heavily reticulated distally, 0.95 the depth of body; Length, 38.0–39.0 μ.

Tropical and subtropical Pacific.

Description: — This is a medium-sized species, with body rounded squarish in lateral outline, deepest in the middle. The ratio between the length and the depth of the body is 1.08–1.11: 1. The longitudinal axis is perpendicular.

The epitheca is about 0.35 as deep as the hypotheca, rather strongly convex, somewhat higher dorsally than ventrally, and subhorizontal. Dorsally the transverse furrow is moderately concave, about 0.48 the greatest depth of the body, but slightly wider than ventrally, and inclined dorsoposteriorly at 40°–45°; ventrally it is gently convex, nearly flat. The distance from the apex to the posterior cingular list is about 0.43 the length of the body. The anterior margin of the hypotheca is gently undulating and subhorizontal. The dorsal, posterior, and

ventral margins of the hypotheca are confluent and well convex; or the hypotheca may be somewhat flattened posterodorsally and posteroventrally. In dorsoventral view the body is urn-shaped, widest at the posterior cingular list; narrowly rounded anteriorly, due to the pronounced concavity of the transverse furrow; and the hypotheca is fairly broadly rounded posteriorly, with evenly convex lateral outlines; the ratio between the length and the width is about 1.34: 1.

The anterior cingular list is sessile, widely flaring, inclined anteriorly at 20°–25°, and about four times wider distally than proximally; its dorsal and ventral extent are subequal, sides concave, equal dorsally and ventrally, and arising at the same level, with horizontal top; its height is about 0.61 the greatest depth of the body, and it has on each valve 8–13 subequidistant, complete radial ribs, all of which are simple except the dorsal one which may have three branches; proximally these ribs are connected by reticulation. The posterior cingular list is closed, somewhat flaring distally, and its dorsal and ventral margins are inclined anteriorly at about 70°; the dorsal and ventral heights are about 0.53 the greatest depth of the body; besides the ribs at the sagittal suture, this list has on each valve two usually simple, straight radial ribs, one of which is in the middle and one ventrally; no reticulation is present. The left sulcal list is of narrow tongue-shape and ends at or near the antapex of the body; it is narrowly rounded posteriorly, the ventral margin between the fission rib and the posterior main rib is gently convex, and the dorsal margin is gently concave. The portion of this list in front of the fission rib is finely reticulated; in the type specimen it is but slightly developed (following fission?), its ventral margin is gently concave, nearly straight, and its posterior width is but slightly more than half the length of the fission rib (Plate 19, fig. 6). The fission rib is straight, about 0.35 the greatest width of the body, and deflected posteriorly at 25°–30°. The posterior main rib is submarginal, very strong, gently concave dorsally, about 0.95 the depth of the body, and deflected posteroventrally at 5°–10°; its distal end is heavily reticulated and fills the posterior portion of the list. Between the fission rib and the posterior main rib this list is faintly reticulated, the meshes being rather large.

The thecal wall is porulate and reticulated, the meshes subuniform and medium-sized, and each of them has one pore in the middle. On each valve about 16 meshes border the girdle posteriorly. There is no record of phaeosomes. Large, round chromatophores (?) are present.

All the dimensions were measured in only one specimen, the type. The length and depth of the body and the total length were measured in three more specimens.

Dimensions: — Length of body, 38.0–39.0 μ (type, 38.0 μ). Greatest depth of body, 35.0–36.0 μ (type, 35.0 μ). Total length, 82–95 μ (type, 83 μ).

Comparisons: — The specimen represented by Okamura (1912, pl. 3, fig. 55) is figured in a very sketchy manner but nevertheless agrees quite closely with the type except in the ventral margin of the left sulcal list, which is strikingly concave just behind the fission rib (due to recent binary fission?). The specimen figured by Murray and Whitting (1899, pl. 32, fig. 4c) as *Histioneis para* may possibly belong to this species, but it differs in the relative depth of the epitheca, in the ribbing of the posterior cingular list, and in having a well-developed rib in the left sulcal list just behind the fission rib.

The closest-known relatives of this species presumably are *Parahistioneis garretti* and *P. para* (regarding the relationship to *P. garretti*, see this species, the section on comparisons). *P. paraformis* recalls *P. para* in having but two ribs in the posterior cingular list, in the narrowly tongue-shaped and reticulated left sulcal list, and in the urn-shape of the body in dorsoventral view. It is easily distinguished from this species by the broader shape of the body seen laterally and by the fact that the strong posterior main rib of the left sulcal list is heavily reticulated distally.

Synonymy: — This species has been recorded and figured previously by Okamura (1912, p. 20, pl. 3, fig. 55) under the name of *Histioneis para*. One of the two specimens represented by Murray and Whitting (1899, pl. 32, fig. 4c) under this name may also be referable to the present species, but this allocation is somewhat uncertain, as mentioned in the last section.

Occurrence: — *Parahistioneis paraformis* is recorded at seven of the 127 stations. There are 0, 0, 0, 2, 5, and 0 stations on the six lines of the Expedition. Of these seven stations one (4697) is in the Easter Island Eddy; and six (4701, 4722, 4724, 4732, 4733, 4734) are in the South Equatorial Drift. At one station (4733) the species was found in the stomach of a Salpa taken in surface waters. All the other records refer to hauls from 300–0 fathoms.

The temperature range of these seven stations at the surface was 75°–81°; the average was 77.7°. At Station 4733 the surface temperature was 80°.

The frequency is in each case less than 1%. The species has previously been recorded from Japanese waters by Okamura (1912) and is presumably widely distributed in tropical and subtropical seas.

Parahistioneis para (Murray and Whitting)

Figure 85: 6

Histioneis para Murray & Whitting, 1899, *partim*, p. 333, pl. 32, fig. 4a, b, tab. 3, 4, 5, 6, 8, 9. Lemmermann, 1899a, *partim*, p. 374; 1901a, p. 376. Cleve, 1901c, p. 252. Kofoid & Michener, 1911, p. 298, 299. non *Histioneis para* Okamura, 1912, p. 20, pl. 3, fig. 55.

Diagnosis: — Body subobovoidal in lateral outline, obliquely truncate anteriorly; length: depth, 1.13–1.44: 1. Dorsally the transverse furrow is moderately to rather strongly concave, 0.37–0.43 the greatest depth of body, 1.5–2.0 times wider than ventrally, and inclined dorsoposteriorly at 35°–40°. Distance from apex to posterior cingular list 0.24–0.27 the length of body. Anterior cingular list sessile, subequal in dorsal and ventral extension, with unequal concave sides; its height 0.50 the depth of body. Posterior cingular list closed, with two simple ribs, one on either side of the middle; its dorsal height 0.39–0.45 the depth of body, with sinuous line of attachment. Left sulcal list narrowly tongue-shaped, ends at antapex, reticulated; R_3 marginal, directed posteriorly, straight or gently sigmoid, of moderate strength, and 0.76–0.97 the depth of body. Length, 43.7–47.0 μ.

Widely distributed in tropical and subtropical seas.

Description: — This is a medium-sized species, with body subobovoidal in lateral outline, obliquely truncate anteriorly, and deepest at the posterior cingular list. The ratio between the length and the depth of the body is 1.13–1.44: 1. The longitudinal axis is perpendicular.

The epitheca is 0.46–0.55 as deep as the hypotheca, flat except dorsally where it is angular or subangular in lateral outline, and tilted ventroposteriorly at 10°–15°. Dorsally the transverse furrow is moderately to rather strongly concave, 0.37–0.43 the greatest depth of the body, 1.5–2.0 times wider than ventrally, and inclined dorsoposteriorly at 35°–40°; ventrally it is flat or gently convex. The distance from the apex to the posterior cingular list is 0.24–0.27 the length of the body. The anterior margin of the hypotheca is nearly straight and subhorizontal. Posteriorly the hypotheca tapers quite decidedly, its posterior end being rather narrowly rounded. The dorsal margin of the hypotheca is gently convex or flattened, the ventral margin gently convex. In dorsoventral view the body is urn-shaped, widest somewhat behind the girdle; narrowly rounded anteriorly, due to the pronounced concavity of the transverse furrow; the hypotheca tapers posteriorly, with evenly and gently convex lateral outlines, and rather narrowly rounded posterior end; the ratio between the length and the width is about 1.66: 1.

The anterior cingular list is sessile and flaring, inclined anteriorly at 20°–25°, and 2.3–2.8 times wider distally than proximally; its dorsal extension is 1.3 the

ventral, sides concave, the ventral steeper than the dorsal; posteriorly its line of attachment declines abruptly, and top horizontal; its height is about 0.50 the depth of the body; and it has on each valve about 10–12 subequidistant, complete radial ribs, all of which are simple (except possibly the dorsal one, which may be branched as in *Parahistioneis paraformis*). The posterior cingular list is closed, slightly flaring distally, and its dorsal and ventral margins are inclined anteriorly at 55°–65°; the dorsal and ventral heights are 0.39–0.45 and 0.43–0.52 the greatest depth of the body; besides the ribs at the sagittal suture, this list has on each valve two simple, straight radial ribs, one on either side of the middle; no reticulation is present. The left sulcal list is of narrow tongue-shape, ends at or near the antapex of the body, and is entirely covered by reticulation. Its ventral margin is gently convex or sigmoid, its dorsal margin is nearly straight or gently sigmoid, and it is narrowly rounded or subacute posteriorly. The posterior main rib is marginal, directed posteriorly, of moderate strength, and 0.76–0.97 the depth of the body.

The thecal wall is reticulate; about 13 meshes border the girdle posteriorly. There is no record of phaeosomes.

The dimensions of one specimen from the material of the Expedition and of the type specimen (Murray and Whitting, 1899, pl. 32, fig. 4a) were measured.

Dimensions: — Our specimen: Length of body, 47.0 μ. Greatest depth of body, 32.6 μ. Total length, 85.2 μ. Type specimen, according to Murray and Whitting (1899, Plate 32, figure 4a): Length of body, 43.7 μ. Greatest depth of body, 38.6 μ. Total length, 87.0 μ.

Comparisons: — *Histioneis* [*Parahistioneis*] *para*, as conceived by Murray and Whitting (1899), evidently includes two species, the one represented by their Plate 32, figure 4a and b, the other by their Plate 32, figure 4c. The specimen represented by the first two (fig. 4a, b) of these figures should be regarded as the type of this species. It is characterized especially by the fact that the hypotheca tapers posteriorly and that the entire left sulcal list is reticulated. The specimen represented by the last (fig. 4c) of these three figures may be referable to *Parahistioneis paraformis*, sp. nov., and is characterized by having the hypotheca subsemicircular in lateral outline and by lacking reticulation in the left sulcal list except at the distal end of the posterior main rib. The specimen of *P. para* found in the material of the Expedition agrees quite closely with the type, except in the smaller relative depth of the body and in the smaller relative width of the cingular lists. We have no records of the structure of the cingular and sulcal lists except what is shown in Figure 85: 6.

The closest-known relatives of *Parahistioneis para* presumably are *P. paraformis* and *P. garretti* (see these two species, the sections on comparisons).

Synonymy: — This species was established by Murray and Whitting (1899, pl. 32, fig. 4a–c) under the name of *Histioneis para*. This specific name should, according to our opinion, be applied to the specimen represented only by their Plate 32, figure 4a and 4b. Their Plate 32, figure 4c, appears to be referable to *Parahistioneis paraformis* (see the last section). Cleve (1901c) does not state whether he found both these forms or only one of them in his material. The specimen figured by Okamura (1912) as *Histioneis para* belongs to *Parahistioneis paraformis*.

Occurrence: — *Parahistioneis para* is recorded at only one (4699) of the 127 stations, on the fourth line of the Expedition in the Easter Island Eddy, from 300–0 fathoms, at a surface temperature of 75°. The frequency is 1%.

Murray and Whitting (1899), who were the first to record this species, found it at sixteen stations in the Atlantic Ocean and in the Caribbean Sea, between lat. 33° 40′ N. and lat. 13° 6′ N. and between long. 31° 20′ W. and long. 78° 44′ W., in surface waters of 75° (62°–82°). Cleve (1901c) found it in the Atlantic, between lat. 33° N. and lat. 24° N. and between long. 31° W. and long. 51° W.; temperature, 70.7°; salinity, 37.22. It should be remembered that this species, as conceived by Murray and Whitting (1899), appears to be heterogeneous (see the section on synonymy). Cleve (1901c) does not give any figures, and so his determinations cannot be checked.

3. Reticulata Group. Of the four members of this group, *Parahistioneis dentata* was not recorded from the material of the Expedition. The remaining ones have been treated in the following order: — *P. karsteni*, *P. reticulata*, and *P. diomedeae*.

Parahistioneis karsteni (Kofoid and Michener)

Plate 19, fig. 2. Figure 93: 2

Histioneis karsteni Kofoid & Michener, 1911, p. 298.

Diagnosis: — Body rounded carafe-shape in lateral outline; with fairly long, nearly erect anterior process; hypotheca semicircular; length: depth, 1.09: 1. Dorsally the transverse furrow is rather strongly concave, 0.52 the depth of body, 2.5 times wider than ventrally, and inclined dorsoposteriorly at 40°–45°. Distance from apex to posterior cingular list 0.41 the length of body. Anterior cingular list with incipient stalk, flaring asymmetrically with twice as much dorsal as

ventral flare and more posterior origin ventrally; its height 0.54 the depth of body. Posterior cingular list closed, lacks structural differentiation; dorsal height, 0.57 the depth of body. Left sulcal list ends on dorsal side of body, 0.64 the depth of body from posterior cingular list; rather strongly convex just behind R_2, acute at R_3; R_2 0.25 the depth of body; R_3 arises 0.27 the depth of body from dorsal end of list, fairly weak, 0.67 the depth of body; reticulated, reticulation weak behind R_2. Length, 28.2 μ.

Eastern tropical Pacific.

Description: — This is a fairly small species, with body of rounded carafe-shape in lateral outline; with a rather long, slightly oblique anterior process, broadly rounded posteriorly and deepest in the middle. The anterior process is slightly deeper than long and has an anterodorsal inclination of about 5°. The ratio between the length and the depth of the body is about 1.09: 1. The longitudinal axis is about perpendicular.

The epitheca is about 0.35 as deep as the hypotheca, well convex, highest near the center, and tilted ventroposteriorly at 15°–20°. Dorsally the transverse furrow is rather strongly concave, about 0.52 the greatest depth of the body, 2.5 times wider than ventrally, and inclined dorsoposteriorly at 40°–45°; ventrally it is gently concave. The distance from the apex to the posterior cingular list is about 0.41 the length of body. The anterior margin of the hypotheca is gently concave and inclined dorsoposteriorly at 5°–10°. The dorsal, posterior, and ventral margins of the hypotheca are confluent and semicircular.

The anterior cingular list has an incipient stalk, is inclined anteriorly at about 40° and is approximately 2.5 times wider distally than proximally; it flares asymmetrically, arising farther posterior ventrally than dorsally, with straight ventral and concave dorsal side, twice as much dorsal as ventral extension, and top with slight posteroventral slope; its height is about 0.54 the greatest depth of the body; and it has on each valve five to six complete, subequidistant radial ribs, all of which are simple except the dorsal one, which has three branches. The posterior cingular list is closed, and its dorsal and ventral margins are subparallel to the longitudinal axis; its dorsal height is about 0.57 the greatest depth of the body; it has no ribs except the dorsal and ventral ones, and it lacks structural differentiation with the exception of a slight ventral reticulation. The left sulcal list is of medium size and ends on the dorsal side of the body at a distance from the posterior cingular list equaling about 0.64 the greatest depth of the body. The ventral margin is gently sigmoid in front of the fission rib; between this rib and the posterior main rib the margin is rather strongly convex anteriorly and

gently sigmoid posteriorly; at the tip of the posterior main rib it is acute, forming an angle of about 85°; the dorsal margin is gently sigmoid, convex anteriorly and concave posteriorly. The fission rib is straight, about 0.25 the greatest depth of the body, and deflected posteriorly at about 25°. The posterior main rib arises at the antapex of the body and about 0.27 the greatest depth of the body from the dorsal end of the list, is fairly weak, gently sigmoid, and directed posteriorly; its length is about 0.67 the greatest depth of the body. Almost the entire list is reticulated, the meshes being of medium size to rather small; behind the fission rib the reticulation is very faint; in front of this rib it is rather pronounced.

The thecal wall is porulate and deeply reticulated, the meshes being subuniform and medium-sized. The pores are located in the meshes, but by far the greater number of the meshes lack pores. On each valve about 15 meshes border the girdle posteriorly. There is no record of phaeosomes.

The dimensions of the type specimen only were measured.

Dimensions: — Type specimen: Length of body, 28.2 μ. Greatest depth of body, 25.8 μ. Total length, 56.6 μ.

Comparisons: — Our description and figure are based on the type specimen.

The shape of the body and the structure of the left sulcal list indicate that this species is rather closely related to *Parahistioneis diomedeae* and *P. reticulata*, two species from which it differs strikingly in being markedly smaller, in having the anterior cingular list characterized by an incipient stalk, and in the shape of the left sulcal list.

Synonymy: — This species was established by Kofoid and Michener (1911) as *Histioneis karsteni*.

Occurrence: — *Parahistioneis karsteni* is recorded at only one of the 127 stations (4619) on the first line of the Expedition in the Panamic Area. Only one specimen was found in a Salpa taken in surface waters of 79°.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4619 of the Expedition, which thus is the type locality.

Parahistioneis reticulata (Kofoid)

Plate 19, fig. 7, 10. Figure 93: 7

Histioneis reticulata Kofoid, 1907a, p. 205, pl. 15, fig. 95. Okamura, 1912, p. 21, pl. 3, fig. 56a, b.

Diagnosis: — Body gourd-shaped in lateral outline; with long oblique anterior process; hypotheca semicircular; length: depth, 1.15–1.35: 1. Dorsally the transverse furrow is very strongly concave, 0.48–0.54 the depth of body, 1.5

as wide as ventrally, and inclined dorsoposteriorly at 50°. Distance from apex to posterior cingular list 0.50 the length of body. Anterior cingular list sessile; its height 0.32–0.40 the depth of body. Posterior cingular list closed, a large part of it finely reticulated; dorsal height 0.34–0.43 the depth of body. Left sulcal list narrow; ends at or somewhat ventrally to antapex; strikingly sigmoid between R_2 and R_3; R_2 0.12 the depth of body; R_3 arises 0.09–0.20 the depth of body from dorsal end of list, strong but not club-shaped, 0.27–0.37 the depth of body; reticulated. Length, 35.9–44.0 μ.

Tropical and subtropical Pacific.

Description: — The body of this medium-sized species is gourd-shaped in lateral outline; with long, oblique anterior process, broadly rounded posteriorly and deepest in the middle. The anterior process is about 1.30 times longer than deep, and has an anterodorsal inclination of about 25°–30°. The ratio between the length and the depth of the body is 1.15–1.35: 1. The longitudinal axis is perpendicular.

The epitheca is about 0.31 as deep as the hypotheca, well convex, highest in or near the center, and subhorizontal. Dorsally the transverse furrow is very strongly concave, 0.48–0.54 the greatest depth of the body, about 1.5 times wider than ventrally, and inclined dorsoposteriorly at about 50°; ventrally it is gently concave. The distance from the apex to the posterior cingular list is about 0.50 the length of the body. The anterior margin of the hypotheca is moderately and somewhat irregularly concave, and inclined dorsoposteriorly at 5°–10°. The dorsal, posterior, and ventral margins of the hypotheca are confluent and semicircular. When seen in dorsoventral view, the body is carafe-shaped, widest in the middle, and strikingly angular at the junction of the transverse furrow and the hypotheca; the transverse furrow is fairly strongly concave; the antapex is rather narrowly rounded; the outlines of the hypotheca are moderately convex, and flattened or even slightly concave posteriorly; length: width, 1.42: 1.

The anterior cingular list is sessile, of equal width and flare ventrally and dorsally, and with no posterior extension ventrally, inclined anteriorly at about 25°, and about 2.7 times wider distally than proximally; its height is 0.32–0.40 the greatest depth of the body; and it has on each valve about 11–14 subequidistant, complete radial ribs, all of which are simple except the dorsal one which has two branches. The posterior cingular list is closed; the membrane that closes the midventral cleft has five equidistant transverse ribs; the dorsal and ventral margins are subparallel to the longitudinal axis, except anteriorly, where the list is flaring; the dorsal height is 0.34–0.43 the greatest depth of the body, the ven-

tral height is slightly less; it has no ribs except the dorsal and ventral ones, but the larger portion of it is finely reticulated. The left sulcal list is relatively narrow and ends at or somewhat ventrally to the antapex of the body. Its ventral margin is nearly straight in front of the fission rib; between this rib and the posterior main rib the margin is strongly sigmoid; at the tip of the posterior main rib it forms an angle of 40°–50°; the dorsal margin is gently convex, nearly straight. The fission rib is nearly straight, about 0.12 the greatest depth of the body, and deflected posteriorly at about 10°. The posterior main rib arises 0.09–0.20 the greatest depth of the body from the dorsal end of the list, is strong but not club-shaped distally, deflected about 30° from the longitudinal axis, and 0.27–0.37 the greatest depth of the body. The entire list is strikingly reticulated, with the meshes of medium to rather small size.

The thecal wall is porulate and areolate, the areoles being medium-sized. The pores are located in the areoles, but not all the areoles have pores. On each valve 20–25 areoles border the girdle posteriorly. Phaeosomes, some small and ellipsoidal, some large and globular, are found in the transverse furrow.

The dimensions of the type only were measured.

Dimensions: — Type specimen: Length of body, 44.0 μ. Greatest depth of body, 38.2 μ. Total length, 55.5 μ (not 115 μ, as stated in the original description). The two specimens figured by Okamura (1912, pl. 3, fig. 56a, b) were 35.9–39.7 μ long and 27.0–29.5 μ deep.

Comparisons: — Our description and figures are based on the type material. The two specimens represented by Okamura (1912, pl. 3, fig. 56a, b) as *Histioneis reticulata* (?) are figured in a very sketchy manner but nevertheless sufficiently detailed for certainty of specific assignment. Although they are somewhat smaller (35.9–39.7 μ, as compared with 44.0 μ) and narrower (ratio between length and depth, 1.33–1.35: 1, as compared with 1.15: 1) than the type specimen, their allocation undoubtedly is correct.

With regard to the position of *Parahistioneis reticulata* within its genus, see *P. diomedeae*, which is the closest-known relative of this species.

Synonymy: — This species was established by Kofoid (1907a) under the name of *Histioneis reticulata*, and this name was used also by Okamura (1912).

Occurrence: — *Parahistioneis reticulata* is recorded at nine of the 127 stations. There are 2, 0, 0, 4, 3, and 0 stations on the six lines of the Expedition. Of these nine stations, two (4598, 4604) are in the Mexican Current; two (4697, 4699) are in the Easter Island Eddy; and five (4701, 4711, 4722, 4733, 4734) are in the South Equatorial Drift. At one station (4604) the species was taken in a surface haul;

at one station (4733) it occurred in a Salpa taken in surface waters; the remaining records refer to hauls from 300–0 fathoms.

The temperature range of these nine stations at the surface was 72°–84°; the average was 77.9°. At the two stations in the surface waters of which this species was found, the surface temperatures were 84° and 80°.

The frequency is less than 1% except at two stations (4598, 4722), where it is 1%.

The species was first recorded by Kofoid (1907a) from Station 4699 of the Expedition which thus is the type locality. Later it was found by Okamura (1912) in Japanese waters. Its absence from the California and Peruvian Currents is noteworthy.

Parahistioneis diomedeae (Kofoid and Michener)

Plate 19, fig. 4, 5. Figure 93: 6

Histioneis diomedeae Kofoid & Michener, 1911, p. 294.

Diagnosis: — Body asymmetrically gourd-shaped in lateral outline, with long, oblique, dorsally deflected anterior process; hypotheca semicircular; length: depth, 1.11: 1. Dorsally the transverse furrow is very strongly concave, 0.43 the depth of body, twice as wide as ventrally, and inclined dorsoposteriorly at 55°. Distance from apex to posterior cingular list 0.47 the length of body. Anterior cingular list sessile, of equal length and flare dorsally and ventrally; its height 0.30 the depth of body. Posterior cingular list closed, in part finely reticulated; dorsal height 0.36 the depth of body. Left sulcal list ends on dorsal side of body, 0.47 the depth of body from posterior cingular list; with two lobes, one rounded, subrectangular at R_2, one narrowly rounded at R_3; R_2 0.33 the depth of body; R_3 arises 0.54 the depth of body from dorsal end of list, club-shaped distally, 0.68 the depth of body; reticulated. Length, 53.5 μ.

Eastern tropical Pacific.

Description: — This is a large species with the body asymmetrically gourd-shaped in lateral outline, with long, oblique anterior process, broadly rounded posteriorly, and deepest in the middle. The anterior process is about 1.25 times longer than deep and has an anterodorsal inclination of about 20°–25°. The ratio between the length and the depth of the body is about 1.11: 1. The longitudinal axis is perpendicular.

The epitheca is about 0.40 as deep as the hypotheca, well convex, somewhat higher dorsally than ventrally, and tilted ventroposteriorly at 15°–20°. Dorsally the transverse furrow is very strongly concave, 0.43 the greatest depth of the

body, about twice as wide as ventrally, and inclined dorsoposteriorly at about 55°; ventrally it is gently concave. The distance from the apex to the posterior cingular list is about 0.47 the length of the body. The anterior margin of the hypotheca is rather strikingly undulating and is inclined dorsoposteriorly at 5°–10°. The dorsal, posterior, and ventral margins of the hypotheca are confluent and semicircular. When seen in dorsoventral view, the body is widest and strongly convex in the middle and has narrowly rounded apices, the outline being gently concave anteriorly and posteriorly; the ratio between the length and the width is 1.58: 1.

The anterior cingular list is sessile, of equal length and flare dorsally and ventrally, inclined anteriorly at about 20°, and about twice as wide distally as proximally; its height is 0.30 the greatest depth of the body; and it has on each valve about 12–14 subequidistant, complete, radial ribs and a number of incomplete, radial marginal ribs; of the complete ribs all are simple except the dorsal one, which has about six branches (Plate 19, fig. 4). The posterior cingular list is closed, and its dorsal and ventral margins are subparallel to the longitudinal axis; its dorsal height is about 0.36 the greatest depth of the body; it has no ribs except the dorsal and ventral ones, and is finely reticulated dorsally and ventrally. The right sulcal list is crescent-shaped and extends to a point somewhat beyond the fission rib of the left sulcal list; its greatest width is about 0.09 the greatest depth of the body, and it is finely reticulated. The left sulcal list ends on the dorsal side of the body at a distance from the posterior cingular list equaling about 0.47 the depth of the body. It is characterized by having two lobes, one rounded, subrectangular at the fission rib, the other narrowly rounded at the tip of the posterior main rib. The ventral margin of this list in front of the fission rib is almost straight throughout; between the fission rib and the posterior main rib the margin is moderately concave; and the dorsal margin is gently sigmoid, convex anteriorly, and concave posteriorly. The fission rib is nearly straight, about 0.33 the greatest depth of the body, and deflected posteriorly at about 15°–20°. The posterior main rib arises somewhat ventrally to the antapex and about 0.54 the greatest depth of the body from the dorsal end of the list, is club-shaped distally, directed posteriorly, and measures about 0.68 the greatest depth of the body. Dorsally to the posterior main rib this list is finely reticulated; its remaining portion is characterized by a somewhat coarser reticulation except anteriorly, and ventrally to the posterior main rib where no structural differentiation is to be found.

The thecal wall has numerous pores, each of which is surrounded by an areole of moderate and subuniform size. On each valve about 30–35 areoles border the

girdle posteriorly. Phaeosomes, some small and ellipsoidal, some large and globular, are found in the transverse furrow.

The dimensions of the type only were measured.

Dimensions: — Type specimen: Length of body, 53.5 μ. Greatest depth of body, 48.2 μ. Total length, 91 μ.

Comparisons: — Our description and figures are based on type material.

The closest-known relative of this species undoubtedly is *Parahistioneis reticulata*, which it resembles in the peculiar gourd-like shape of the outline of the body in lateral view and in the shape and structure of the cingular lists. It is very easily distinguished from this species by its larger size, and by its large, two-lobed left sulcal list, the posterior main rib of which is very long and club-shaped distally. Another close relative is *Histioneis* [*Parahistioneis*] *dentata* Murray and Whitting (1899, pl. 33, fig. 4a, b), which it resembles especially in the shape of the body in lateral as well as in dorsoventral view, and to a less degree in the shape of the posterior portion of the left sulcal list. *Parahistioneis dentata* differs strikingly from the present species in the peculiarly serrated anterior edge of the anterior cingular list and in having the anterior margin of the left sulcal list thickened. The shape of its body and the structure of its left sulcal list also suggest comparatively close relationship to *P. karsteni*, a very small species lacking a lobe in the left sulcal list at the fission rib and having a slightly stalked anterior cingular list.

Occurrence: — *Parahistioneis diomedeae* is recorded at four of the 127 stations. There are 1, 0, 0, 1, 2, and 0 stations on the six lines of the Expedition. Of these four stations, one (4619) is in the Panamic Area; one (4699) is in the Easter Island Eddy; and two (4720, 4724) are in the South Equatorial Drift. At one station (4720) the species was taken in a surface haul; at one station (4619) it occurred in a Salpa taken in surface waters; the two remaining records refer to hauls from 300–0 fathoms.

The temperature range of these four stations at the surface was 75°–79°; the average was 77.3°. At Stations 4619 and 4720 the temperature was 79° and 76°, respectively.

The frequency is less than 1% except at Station 4619 where it is 2%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4720. The type specimen is from Station 4699.

Histioneis Stein

Histioneis Stein, 1883, p. 25. Bütschli, 1885, p. 943, 1010. Schütt, 1896, p. 29. Delage & Hérouard, 1896, p. 386.
Histoneis Ostenfeld & Schmidt (*lapsus pennae*), 1901, p. 173.

Diagnosis: — Body of diverse shapes, usually deeper than long; ratio between length and depth, 0.32–1.33: 1. Epitheca small, low, disk-like; its depth 0.07–0.24 the depth of body. Transverse furrow wide dorsally and decidedly wider dorsally than ventrally; dorsal width 0.37–0.77 the depth of body; ventral width 0.09–0.50 the dorsal width. Cingular lists large, closed; anterior funnel-like and stalked (except in *Histioneis paulseni*), its dorsal height 0.57–2.00 the depth of body, its structure variable; posterior usually subcylindrical, its dorsal height 0.47–1.10 the depth of body, and always with one dorsal and one ventral pair of ribs and one cross-rib. Left sulcal list usually large, of diverse shapes, in most species narrowly to broadly tongue-shaped, its greatest width varying from 0.30 to 2.14 the depth of body, and never with more than one main rib behind fission rib.

Type: — We designate as the type species of the genus, *Histioneis remora* Stein (1883, explanation of his pl. 22, fig. 11).

Organology: — The *body* (*theca*) in Histioneis is more diverse in shape than in any of the other large genera of Dinophysoidae, ranging from quite simple to very aberrant types. When seen laterally, it always is more or less asymmetrical, due largely to the shape of the transverse furrow and to the posterodorsal inclination of the longitudinal axis. The hypotheca, however, is symmetrical or subsymmetrical in some of the primitive species. In dorsoventral view the body appears always to be symmetrical just as in the other genera of this tribe. The minimum posterodorsal inclination of the longitudinal axis (*l.a.*, Figure 94) is about 5°–10° (*H. inornata* and *H. inclinata;* Figure 95: 10, 13); the maximum inclination is 50°–60° (*H. josephinae*, Figure 96: 7). The inclination, which is somewhat variable even within the species, is difficult to determine with accuracy, since the antapex is not clearly marked in most species. The information given on this point in our descriptions of species should thus be regarded as approximative.

When seen laterally, the *body* sometimes (*e.g.*, *Histioneis inclinata*, Figure 95: 13; *H. remora*, Stein, 1883, pl. 22, fig. 11) is about as long as deep, but usually it is deeper than long. In the species with the most pronounced dorsoventral elongation (*H. mitchellana*, Figure 96: 4), the ratio between the length and the depth of the body is 0.32–0.53: 1. *H. panda*, in which this ratio is about 0.36: 1, has a curved, sausage-shaped body with an average height only about 0.23 the depth, measured along the curvature of the body (Figure 95: 9). In only two of the known species (*H. biremis* and *H. highleyi;* Figure 95: 11, 14) the body is

longer than deep; in the latter species the ratio between the length and the depth may be as high as 1.33: 1.

There is no shape of *body* that can be said to be typical of this genus. In most of the more or less primitive and in some of the highly differentiated species,

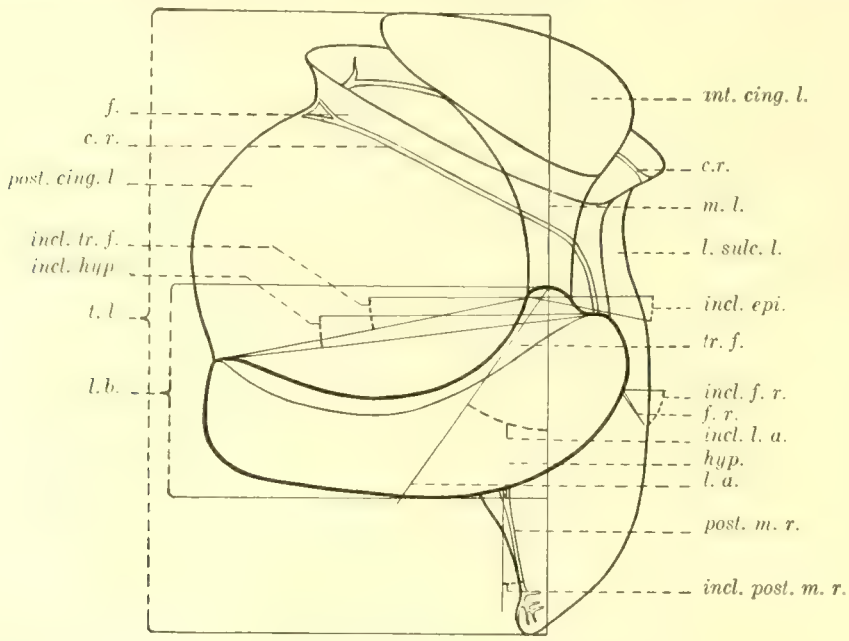

FIGURE 94.— Terminology and methods of measurement in Histioneis.

Terminology: — The midline is the line drawn through the center of the epitheca and the central axis of the proximal portion of the anterior cingular list. If the longitudinal axis of the body were not inclined, it would coincide with the midline. In the specimen represented by this figure the longitudinal axis of body is inclined *posterodorsally*, the transverse furrow *dorsoposteriorly*, and the epitheca *ventroposteriorly*. The fission rib (R_2) is the rib of left sulcal list at place where this list is divided in binary fission. The posterior main rib (R_3) is the rib of left sulcal list near posterior end of this list, or, in the case that more than one rib is present in this region, the best developed of these. The frill is the portion of posterior cingular list in front of cross-rib, *i.e.*, the rib that in the more or less primitive species runs about parallel to anterior margin of this list.

Methods of Measurement: — Measurements are made in straight lines, if not otherwise stated. Proportions of theca measured as if all parts were in the same plane, *i.e.*, as they appear in drawings. The length of body is distance between the two perpendiculars to midline that pass through the apices of body. The depth of body is measured perpendicularly to midline. The inclination of longitudinal axis of body is the angle between this line and midline. The depth of epitheca is measured along base of anterior cingular list. The dorsal width of transverse furrow is measured in a straight line between dorsal points of epitheca and hypotheca when it is compared with the depth of body, and along curvature of furrow between these two points when it is compared with the ventral width of the furrow. The inclination of this furrow is the angle between a perpendicular to midline and the line joining the dorsal points of epitheca and hypotheca. The inclination of the epitheca and of the hypotheca also refers to a perpendicular to midline. The widths (heights) of cingular lists are measured in straight lines dorsally, when the organism is seen in lateral view. The position of posterior cingular list is expressed in the ratio between the shortest distance from apex to this list and the length of the base of this list, measured along the curvature. The inclination of R_2 is the angle between this rib and a perpendicular to midline. The inclination of R_3 is the angle between this rib and a line drawn parallel to midline and through base of rib.

Abbreviations: — *ant. cing. l.*, anterior cingular list; *c. r.*, cross-rib of posterior cingular list; *f.*, frill of posterior cingular list; *f. r.*, fission rib; *hyp.*, hypotheca; *incl. epi.*, inclination of epitheca; *incl. f. r.*, inclination of fission rib; *incl. hyp.*, inclination of hypotheca; *incl. l. a.*, inclination of longitudinal axis; *incl. post. m. r.*, inclination of posterior main rib; *incl. tr. f.*, inclination of transverse furrow; *l. a.*, longitudinal axis; *l. b.*, length of body; *l. sulc. l.*, left sulcal list; *m. l.*, midline; *post. cing. l.*, posterior cingular list; *post. m. r.*, posterior main rib; *t. l.*, total length; *tr. f.*, transverse furrow.

the body, seen in lateral view, is subrotund (*Histioneis costata*, Figure 95: 4; *H. inclinata*, Figure 95: 13) or subrotund and truncate anteriorly (*H. inornata*, Figure 95: 10; *H. reginella*, Figure 95: 2) with symmetrical or subsymmetrical hypotheca. Other shapes of body, seen laterally, recorded in this genus are as follows: — pyriform, with the long axis in the horizontal plane and the greatest height dorsally (*H. hyalina*, Figure 95: 5); bean-shape (*H. pacifica*, Figure 95: 12); short to long canoe-shape, higher ventrally than dorsally (*H. carinata*, Figure 95: 1; *H. navicula*, Figure 95: 3); long canoe-shape, higher dorsally than ventrally (*H. mitchellana*, Figure 96: 4); short to long saddle-shape (*H. dolon*, Figure 96: 6; *H. josephinae*, Figure 96: 7; *H. pulchra*, Figure 96: 2); curved sausage-shape (*H. panaria*, Figure 95: 6; *H. panda*, Figure 95: 9); irregular, dorsoventrally elongated, with fairly long and narrow, well-marked posterodorsal protuberance (*H. biremis*, Figure 95: 11); Y-shape (*H. highleyi*, Figure 95: 14). Between most of these shapes transitions are to be found. Judging by the very limited number of specimens of each species available at the present writing, the shape of the body appears to be fairly constant within the species; see, for instance, Figure 97 and 98 of *H. biremis* and *H. highleyi*.

The *body* is always more or less compressed bilaterally. In some of the species with the body elongated dorsoventrally, the body is about as long as wide in dorsoventral view; and in the species with the most pronounced bilateral compression (*Histioneis costata*, Plate **20**, fig. 10; *H. navicula*, Plate **21**, fig. 3), the ratio between the length and the transdiameter (width) is about 1.6: 1. In the species with the body subrotund in lateral outline, the hypotheca usually is ellipsoidal in dorsoventral view, and the anterior portion of the body is rounded conical (*H. costata*, Plate **20**, fig. 10; *H. longicollis*, Plate **20**, fig. 5). In the more highly differentiated species, with the body more or less elongated dorsoventrally, the body, as a rule, is subrotund to pear-shaped in dorsoventral outline, more or less broadly rounded posteriorly (*e.g.*, *H. carinata*, Plate **21**, fig. 1; *H. pulchra*, Plate **21**, fig. 4; *H. hippoperoides*, Plate **23**, fig. 1).

One of the most characteristic features of Histioneis, when compared with Ornithocercus, is the strikingly small size of the *epitheca*. This structure forms an ellipsoidal to subcircular, gently vaulted to flat disk, the depth of which in lateral view is from about 0.07 to about 0.24 the greatest depth of the hypotheca (*H. panda*, Figure 95: 9; *H. costata*, Figure 95: 4). In some species (*e.g.*, *H. pacifica*, Figure 95: 12) it is subhorizontal; in others it is inclined dorsoposteriorly or ventroposteriorly at somewhere between 1° and 15° (*e.g.*, *H. dolon*, Figure 96: 6; *H. navicula*, Figure 95: 3).

Due to the small size of the epitheca, the *transverse furrow* (*tr. f.*, Figure 94) is always situated near the anterior end of the body. Its distal portion is not displaced posteriorly, *i.e.*, it does not form a spiral about the body; and its postmargin very seldom is straight but usually more or less concave or sigmoid. In all the known species it is strikingly wider dorsally than ventrally, its ventral width being from about 0.50 to about 0.09 the dorsal width (*Histioneis paulseni*, Figure 95: 8; *H. navicula*, Figure 95: 3). Dorsally it either is inclined dorsoposteriorly or dorsoanteriorly, or it is subhorizontal. Dorsoposterior inclination is found among primitive as well as among advanced species (*H. costata*, Figure 95: 4; *H. biremis*, Figure 95: 11); the same is true in the case of the subhorizontal position (*H. inornata*, Figure 95: 10; *H. mitchellana*, Figure 96: 4); but dorsoanterior inclination is found only among the highly differentiated members (*e.g.*, in the PULCHRA and DOLON groups). The maximum dorsoposterior inclination hitherto recorded is about 35° (*H. paulseni*, Figure 95: 8); and the maximum dorsoanterior inclination is about 30° (*H. josephinae*, Figure 96: 7). Sometimes the transverse furrow is nearly flat, sometimes gently to strongly concave. It is flat or nearly so among primitive as well as advanced species (*H. costata*, Figure 95: 4; *H. reginella*, Figure 95: 2); a moderate concavity is also found among both primitive and advanced species (*H. paulseni*, Figure 95: 8; *H. biremis*, Figure 95: 11); on the other hand, a strong concavity has been recorded only among the highly differentiated members (*H. highleyi*, Figure 95: 14; *H. josephinae*, Figure 96: 7). The strong concavity and the great dorsal width of the transverse furrow are correlated with the tendency inherent in this genus to increase the space enclosed by the posterior cingular list. The ratio between the dorsal width of this furrow (measured in a straight line between the dorsal points of the epitheca and of the hypotheca) and the greatest depth of the body ranges from about 0.37: 1 (*H. hippoperoides*, Figure 96: 5) to 0.77: 1 (*H. navicula*, Figure 95: 3). Ventrally this furrow is either flat, or gently concave or convex. The distance from the apex to the posterior cingular list sometimes (*H. paulseni*, Figure 95: 8) is as much as about 0.43 the length of the body, but usually it is very small.

The length of the *longitudinal furrow* is unknown in most species, but judging by the available data it seems nearly always to be short. This furrow has not been found as yet to extend far beyond the fission rib of the left sulcal list, and it appears usually to end at or very near to this rib, which, as a rule, originates but a short distance behind the transverse furrow. Anteriorly it does not extend beyond the girdle, *i.e.*, into the epitheca; and it is at most but slightly impressed.

Just as in Ornithocercus, the *lists of the furrows* are very large, and frequently

FIGURE 95.— Histioneis, right lateral view. × 700. 1, *H. carinata* Kofoid, Station 4724 (300–0 fathoms); 2, *H. reginella* Kofoid and Michener, Station 4681 (300–0 fathoms); 3, *H. navicula* Kofoid, Station 4734 (300–0 fathoms); 4, *H. costata* Kofoid and Michener, Station 4604 (surface); 5, *H. hyalina*

they are also characterized by their high structural differentiation. They arise from low and narrow basal ridges (Plate 20), and although large, they are always hyaline and very delicate.

The *anterior cingular list* (*ant. cing. l.*, Figure 94) is closed and funnel-shaped, and its anterior inclination is at least about 40° on the dorsal side. On the ventral side the inclination is always somewhat steeper than dorsally. With only one known exception, viz., the primitive *Histioneis paulseni* (Figure 95: 8), this list is stalked, *i.e.*, its proximal end forms a narrow tube of subuniform caliber. The stalk may be short, as in *H. costata* (Figure 95: 4); of moderate length, as in *H. carinata* and *H. navicula* (Figure 95: 1, 3); or very long, occupying by far the greater portion (three-fourths) of the very extended list, *e.g.*, in *H. hyalina*, *H. longicollis*, and *H. inornata* (Figure 95: 5, 7, 10). In the most primitive as well as in some of the highly differentiated species, this list has a very pronounced distal flare, and nearly always the dorsal flare is decidedly stronger than the ventral (*H. costata* and *H. mitchellana;* Figure 95: 4; Figure 96: 4). In other species the distal flare is moderate (*H. longicollis*, Figure 95: 7) to very slight (*H. striata* and *H. hippoperoides;* Figure 96: 1, 5). In the species with the most pronounced distal flare (*H. mitchellana*, Figure 96: 4) this list may be as much as about 13 times wider distally than proximally; while in *H. hippoperoides* (Figure 96: 5), which forms the opposite extreme, the corresponding value may be as low as 2. Sometimes (*e.g.*, *H. costata* and *H. carinata;* Figure 95: 4, 1) the right side of this list is distinctly lower than the left, sometimes (*e.g.*, *H. pulchra* and *H. mitchellana;* Figure 96: 2, 4) there is no such difference. In some species (*e.g.*, *H. reginella*, *H. dolon*, and *H. josephinae;* Figure 95: 2; Figure 96: 6, 7) this list has a more or less pronounced ventral notch; and it may be characterized by a dextral torsion (*e.g.*, *H. reginella* and *H. panaria;* Figure 95: 2, 6). Its dorsal height ranges from 0.57 to 2.00 the greatest depth of the body (*H. paulseni* and *H. dolon;* Figure 95: 8; Figure 96: 6); and its ventral height is nearly always somewhat less and never greater than the dorsal. The structural differentiation of this list is characterized by two outstanding peculiarities: — first, it is much more regular among the primitive than among the advanced species; and, second, it is asymmetrical, being, as a rule, better developed on the left than on the right valve.

This phenomenon of the more advanced development of structures on the

Kofoid and Michener, Station 4720 (surface); 6, *H. panaria*, sp. nov., Station 4724 (300–0 fathoms); 7, *H. longicollis* Kofoid, Station 4711 (300–0 fathoms); 8, *H. paulseni* Kofoid, Station 4711 (300–0 fathoms); 9, *H. panda* Kofoid and Michener, Station 4724 (300–0 fathoms); 10, *H. inornata* Kofoid and Michener, Station 4720 (Salpa); 11, *H. biremis* Stein, Station 4709 (300–0 fathoms); 12, *H. pacifica*, sp. nov., Station 4741 (Salpa); 13, *H. inclinata* Kofoid and Michener, Station 4720 (Salpa); 14, *H. highleyi* Murray and Whitting, Station 4722 (300–0 fathoms).

left side is a fundamental one in the Dinoflagellata. The transverse flagellum proceeds from left to right, the left sulcal list is more developed than the right, the ocellus is on the left side, and the intercalary plate of Heterodinium is on the left shoulder. The fact that the centrosome lies in this region (Hall, 1924, 1925) and that the flagella have their origin here, though emerging through the pore in the right valve, is significant in this connection.

The asymmetry is, generally speaking, more pronounced in the primitive than in the highly advanced members. The most primitive condition, resembling that of the species of Ornithocercus, is to be found in *Histioneis paulseni* (Plate **20**, fig. 1, 2), the only species in which this list is not stalked. In this species there are on the right valve about six ribs, all of which are simple except the dorsal one, which has three branches; on the left valve the number of ribs in this list is slightly greater. *H. costata* (Plate **20**, fig. 3), another primitive species, has the difference between the halves still more accentuated. In this species there are on the right valve only three ribs, of which the dorsal and ventral are simple, while the middle has two branches; on the left valve this list has distally about fifteen ribs, the proximal ends of which form a reticulum. About the same condition as in the latter species is also found in *H. carinata*, *H. navicula*, and *H. biremis*, and in some of their close relatives (Plate **21**, fig. 1, 3, 8). The branching of the dorsal rib of the left half or of both the left and right halves is a feature presumably characteristic of the ancestral forms of Histioneis (compare *Ornithocercus formosus*, Plate **17**, fig. 4, and the species of Parahistioneis, Plate **19**). In some of the highly advanced members of Histioneis, this list is reticulated; the reticulation is either more or less developed, wide meshed, and irregular, as in *H. josephinae* (Plate **22**, fig. 1–3), or it is fine meshed, as in *H. mitchellana* (Plate **21**, fig. 2). In others of these highly developed forms this list may have, besides some irregular and sometimes reticulated ribs, a submarginal rib with a series of subequidistant anterior branches (*H. reginella* and *H. hippoperoides;* Plate **20**, fig. 9; Plate **23**, fig. 1, 3). Or, again, it may be nearly without structural differentiation, as in *H. longicollis* (Plate **21**, fig. 5). In all these advanced species the ribbing is limited to the distal portion of the list; the stalk lacks structural differentiation. It may finally be mentioned that in some species (*e.g.*, *H. costata* and *H. josephinae;* Plate **20**, fig. 3; Plate **22**, fig. 2) the tips of the ribs extend slightly beyond the edge of the list.

When fully developed, the *posterior cingular list* (*post. cing. l.*, Figure 94) is closed except posteroventrally, where it probably always opens into the canal formed by the right sulcal list. The presence of this canal has not been established as yet, but appears very probable on account of the peculiar structure of the right

sulcal list (see Plate 20, fig. 7, of *Histioneis elongata*). In some of the specimens figured by us (*H. carinata*, *H. biremis*, and *H. josephinae;* Figure 95: 1, 11; Figure 96: 7) the posterior cingular list has a ventral split, but this is presumably but a temporary condition, possibly attending fission, since specimens with and without such a split have been found in the same species (*H. biremis*). In the most primitive species (*H. costata*, *H. paulseni*, *H. inclinata;* Figure 95: 4, 8, 13) this list forms a cylindrical, upright collar of moderate height, about as high ventrally as dorsally or but slightly lower ventrally than dorsally, with nearly straight or but slightly sigmoid dorsal, ventral, and lateral outlines, and with the anterior opening subequal to the basal circumference. The minimum height on the dorsal side is about 0.47 the greatest depth of the body (*H. paulseni*, Figure 95: 8). From this fundamental type a fairly great number of variants have evolved. In some species this list has maintained its original shape but has increased very strikingly in height; as examples of this kind we may mention *H. longicollis* and *H. mitchellana* (Figure 95: 7; Figure 96: 4), in which the dorsal height is 0.91 and 1.10 the greatest depth of the body, respectively. In other species the main change consists in the decided difference between the dorsal and ventral heights; for instance, in *H. highleyi* (Figure 95: 14) the average dorsal height is 0.62, the average ventral height 0.37 the greatest depth of the body. In *H. elongata* (Figure 96: 3) this list is not only higher than in the primitive species, but it is characterized also by a pronounced difference between the dorsal and ventral heights, the dorsal height being about 0.95, the ventral 0.72 the greatest depth of the body. The greatest dorsal height recorded as yet, viz., 1.40–1.42 the greatest depth of the body, was found in *H. dolon* (Figure 96: 6), a species in which this list is characterized also by other changes (see below).

In *H. carinata* (Figure 95: 1) this list grows narrower anteriorly; and this peculiarity reaches its most striking development in *H. panda* (Figure 95: 9), which is characterized by a very narrow anterior opening and a very large basal circumference. In other forms (*e.g.*, *H. navicula*, Figure 95: 3) it is more or less strongly constricted just behind the anterior margin, which thus becomes flaring. *H. inornata* (Figure 95: 10) is characterized by having the anterior opening of this list wider than the basal circumference. In some species the dorsal margin of this list is evenly or irregularly concave (*H. josephinae* and *H. hippoperoides;* Figure 96: 7, 5); in others it is more or less bulging (*H. navicula*, Figure 95: 3). Perhaps the most important change in the shape of this list is due to the development of lateral pouches, one on each side. The pouches are fairly small in some species (*e.g.*, in *H. pulchra* and *H. dolon;* Plate 21, fig. 4; Murray and Whitting,

1899, pl. 33, fig. 5b); in others (*e.g.*, *H. hippoperoides*, Plate **23**, fig. 1) they are of medium size; and they reach their greatest size in *H. panda*, *H. panaria*, and *H. reginella* (Figure 95: 9; Figure 85: 8; Plate **20**, fig. 11). In *H. panaria* the pouches are broadly rounded in dorsoventral view, and each of them is slightly wider than the body; in *H. reginella* they are fairly narrowly rounded, and each of them is slightly narrower than the body.

The structural differentiation of this list is simple and uniform in the primitive species. These have only a pair of simple, dorsal ribs, one rib on either side of the sagittal suture, a similar pair ventrally, and a simple cross-rib running submarginally to the anterior edge of the list, turning posteriorly on the ventral side of it, and connecting with the dorsal ribs. The portion of the list in front of the cross-rib is called the *frill*. From this fundamental type, which can be recognized even in the most advanced members of the genus, some variants have evolved. First, there is a tendency among the advanced species for the frill to become progressively higher. For example, in *H. mitchellana* (Figure 96: 4) it is decidedly larger than the rest of the list. The enlargement of the frill, which is more pronounced on the dorsal side of the list than in the middle, and which progresses until the cross-rib issues from near the base of the dorsal ribs (Figure 96: 6), is in some species (*e.g.*, *H. pacifica*) the only change to be recorded. Second, the cross-rib tends to be branched. Branches may be developed only on its anterior side, in other words in the frill (*e.g.*, *H. panaria*, Figure 95: 6), or on both its anterior and its posterior sides (*e.g.*, *H. reginella*, Figure 95: 2). The branches of this rib are first simple and nearly straight, but they tend to become irregular and branched, and to form a wide-meshed or a fine-meshed reticulum (*H. pulchra*, Figure 96: 2; *H. mitchellana*, Plate **21**, fig. 2). Third, accessory ribbing usually is confined to the frill (*H. mitchellana*, Plate **21**, fig. 2) and is always better developed anteriorly than posteriorly. Irregular ribs may develop posteriorly; for instance, on the lateral pouches of *H. reginella* (Plate **20**, fig. 9, 11) and from the postmargin of this list in *H. hippoperoides* (Plate **23**, fig. 1). Fourth, in some of the species with a high frill a secondary frill is present (*H. panda*, Figure 95: 9; and the species of the Dolon group, Figure 96: 6). The cross-rib that borders this secondary frill may be either simple or branched, and the branches may be present only on the anterior side (*H. dolon*, Figure 96: 6), or anteriorly as well as posteriorly (*H. hippoperoides*, Figure 96: 5).

The *right sulcal list* is known in two species only, viz., in *Histioneis elongata* (Plate **20**, fig. 7) and in *H. josephinae* (Figure 96: 7), and in these it is very small and difficult to detect. In the former species, which may present the condition

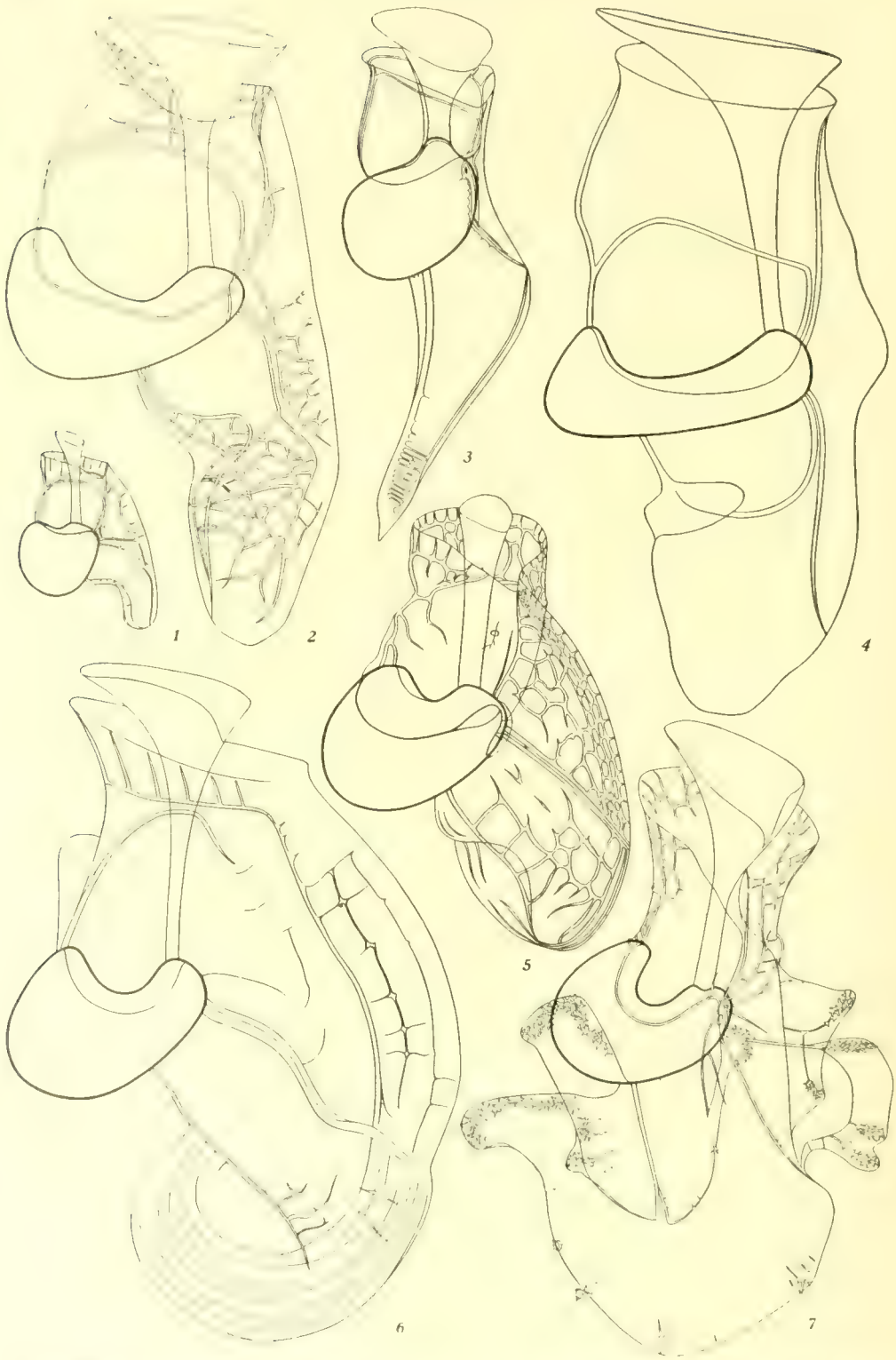

FIGURE 96 — Histioneis, right lateral view. × 700. 1, *H. striata* Kofoid and Michener, Station 4720 (Salpa); 2, *H. pulchra* Kofoid, Station 4730 (300–0 fathoms); 3, *H. elongata* Kofoid and Michener,

primitively typical of this genus, the ventral margin of this list is attached to the base of the left sulcal list. Thus a canal is formed, which opens posteriorly at the fission rib of the left sulcal list and presumably also into the girdle. The water caused by the movements of the transverse flagellum to enter the girdle probably passes out through this canal. In *H. josephinae* the right sulcal list continues beyond the margin of the theca to a distance slightly greater than from that point to the flagellar pore; it is very narrow at this pore, lanceolate posteriorly, and has a rib along the dorsal margin.

The *left sulcal list* (*l. sulc. l.*, Figure 94), which usually is rather large, has undergone very profound structural modifications and affords very important taxonomic features; indeed, the systematic subdivisions of this genus suggested by us are to a very large extent based on differences in this list. In only two of the known species (*Histioneis costata* and *H. mitchellana;* Figure 95: 4; Figure 96: 4) does this list extend slightly beyond the antapex of the body; in the remaining species it ends somewhere between the antapex and the point midway between the antapex and the flagellar pore. In *H. inclinata* (Figure 95: 13), which is characterized by having this list smaller than in any of the other members of this genus, this list ends about midway between the antapex and the flagellar pore, and its maximum width is about 0.30 the greatest depth of the body. In *H. dolon* (Figure 96: 6), which has this list of an extraordinary size, it ends at about the same place as in *H. inclinata*, but its width at the fission rib and at the posterior main rib equals not less than 1.45–1.61 and 1.70–1.80 the greatest depth of the body. Finally, in *H. elongata* (Figure 96: 3), which has this list unusually long and narrow, the posterior main rib of this list measures not less than about 2.14 the greatest depth of the body (in the case of the fission rib of this species, the corresponding value is not more than about 0.57). In one species (*H. reginella*, Figure 95: 2) the posterior portion of this list turns anteriorly on the right side of the body and ends near the posterior end of the longitudinal furrow. In all the known species except one (*H. inclinata*, Figure 95: 13) the portion of this list which is in front of the fission rib is decidedly smaller than the posterior; and it is this posterior portion which has been especially subject to structural differentiation.

The shape of this list is exceedingly variable, as will be seen from the following representative examples. In *H. inornata* (Figure 95: 13) this list is very short, not extending even to the level of the antapex of the body, of subuniform width

Station 4722 (300–0 fathoms); 4, *H. mitchellana* Murray and Whitting, Station 4699 (300–0 fathoms); 5, *H. hippoperoides* Kofoid and Michener, Station 4590 (300–0 fathoms); 6, *H. dolon* Murray and Whitting, Station 4697 (300–0 fathoms); 7, *H. josephinae* Kofoid, Station 4699 (300–0 fathoms).

throughout and very narrow, its maximum width being only about 0.30 the greatest depth of the body; its ventral margin is gently sigmoid, concave anteriorly, and convex posteriorly; and its postmargin is subcircular. In *H. inclinata* (Figure 95: 10) this list differs from that of the latter species mainly in being slightly longer, extending somewhat beyond the level of the antapex of the body, and in having the postmargin sigmoid instead of subcircular. The left sulcal list of *H. navicula* (Figure 95: 3) is also comparatively small, ending somewhat ventrally to the antapex and having a maximum width, at the posterior main rib, only 0.36 the greatest depth of the body; its ventral margin is moderately and evenly convex, its dorsal margin gently concave, and these margins form together an angle of 60°–70° at the posterior main rib. In *H. costata* (Figure 95: 4) this list is fairly large, extending slightly beyond the antapex and with a maximum width (at the posterior main rib) about 0.67 the greatest depth of the body, and squarish in shape, its margin being angular somewhat behind the fission rib as well as at the posterior main rib. This is the only example of biangularity known in this genus. In many species (*e.g.*, *H. carinata*, *H. hyalina*, *H. paulseni*, *H. pacifica*, Figure 95: 1, 5, 8, 12; *H. pulchra*, *H. elongata*, Figure 96: 2, 3) this list is large and of a narrow tongue-shape; its ventral margin is gently convex or sigmoid; its dorsal margin, gently concave, straight, gently convex, or sigmoid; and posteriorly, *i.e.*, at the posterior main rib, it is acute to subacute, or narrowly to rather broadly rounded. Finally, in some species (*e.g.*, *H. hippoperoides* and *H. dolon*, Figure 96: 5, 6) this list is very large (see above) and broadly tongue-shaped; and in *H. josephinae* (Figure 96: 7) it is very large, broadly rounded posteriorly, and furnished with a narrowly rounded dorsal projection, the length of which is approximately 0.6 the greatest depth of the body. Originally this list was but slightly or gently curved, and this condition is still characteristic of most of the known species (see, for instance, *H. paulseni* and *H. costata*, Plate **20**, fig. 2, 10; *H. carinata* and *H. navicula*, Plate **21**, fig. 1, 3; *H. elongata*, Plate **22**, fig. 4). Sometimes, however, its entire dorsal margin is strongly curled to the right (*H. hyalina*, Figure 95: 5; *H. striata*, Figure 96: 1). This peculiarity is further advanced in *H. pulchra* (Figure 96: 2), in which the middle portion of this margin forms a fairly large, narrowly rounded lobe. It reaches its highest development in *H. mitchellana* (Figure 96: 4); in this species the lobe is represented by a very circumscribed, tongue-shaped to subcircular flap, the dorsoventral width of which is 0.34–0.38 the greatest depth of the body. In *H. navicula* (Plate **21**, fig. 6) the ventral margin is turned to the right; and in *H. reginella* (Plate **20**, fig. 9) the entire list is strongly curled to the right.

In the species of the DOLON group this list is characterized by one to three accessory fins. When only one accessory fin is developed (*H. dolon* and *H. hippoperoides;* Figure 96: 6, 5), this is always posterodorsal and transverse in position. Its shape usually is rounded (*H. dolon*, Murray and Whitting, 1899, pl. 33, fig. 5b) but may be pear-like (*H. milneri*, Murray and Whitting, 1899, pl. 33, fig. 1b). It is either (*H. dolon*) very large, with a diameter not less than 1.64 the depth of the body; or (*H. milneri*) of moderate size, its diameter being only about 0.70 the depth of the body. More than one accessory fin is present in only one of the known species, viz., *H. josephinae* (Figure 96: 7). One of these fins arises along the originally free ventral edge of the list in front of the fission rib, one from the left side of the fission rib, and one, or perhaps better a pair, transversely from the posterior main rib; the first two fins are large and squarish, the last is large and shaped like a pair of butterfly wings.

In no species of this genus does this list have more than two main ribs, viz., the fission rib and the posterior main rib. The *fission rib* (*f. r.*, Figure 94) originally was straight and subhorizontal, and this condition still prevails in some of the primitive species (*H. inornata* and *H. inclinata;* Figure 95: 10, 13). Usually, however, it is more or less deflected posteriorly, and this progressive deflection has reached its maximum in *H. mitchellana* (Figure 96: 4), in which the anterior member of this rib is directed straight posteriorly. Originally the two members of this rib were lying close together along their entire extension, but in the species of the LONGICOLLIS and PULCHRA groups the posterior member is recurved dorsally and joins the posterior main rib near the middle. In the primitive and in some of the advanced species the fission rib is very short, its minimum length being about 0.12 the greatest depth of the body (*H. navicula*, Figure 95: 3); but it shows a tendency to become progressively longer and in *H. dolon* (Figure 96: 6) it reaches its maximum length, viz., 1.61 the greatest depth of the body. The *posterior main rib* (*post. m. r.*, Figure 94), which is absent in only one of the known species (*H. inclinata*, Figure 95: 13), usually is marginal or submarginal, enforcing the dorsal edge of the list. Only in one species (*H. josephinae*, Figure 96: 7) does it run far from the dorsal margin, and even in this species it arises near the dorsal end of the list. As a rule, this rib extends to the posterior end of the list, but it may be only about half as long as the posterior width of the list (*H. josephinae*, Figure 96: 7). Its length and strength are very variable; it may be weak and only about 0.22 the greatest depth of the body (*H. inornata*, Figure 95: 10), or strong and not less than 2.14 the greatest depth of the body. In only one of the known species (*H. costata*, Figure 95: 4) is it deflected posterodorsally (at about 15°); in the remain-

ing ones it is more or less deflected posteroventrally. Its shape is variable; it may be almost straight (*H. costata*, Figure 95: 4), gently sigmoid (*H. carinata*, Figure 95: 1), or gently to fairly strongly concave dorsally (*H. elongata* and *H. striata;* Figure 96: 3, 1).

Besides the main ribs this list may have the following structural differentiations. First, a few short (incomplete) ribs between the fission rib and the posterior main rib (*H. paulseni*, Figure 95: 8). Second, one to four submarginal ribs along the ventral margin in front of the fission rib (*H. hippoperoides* and *H. dolon;* Figure 96: 5, 6); and one marginal or one submarginal rib along the ventral margin behind the fission rib (*H. paulseni* and *H. elongata;* Figure 95: 8; Figure 96: 3). Third, a number of radial ribs behind the fission rib (*H. inclinata*, Figure 95: 13). Fourth, a wide-meshed or a fine-meshed reticulum. The reticulum varies in extension; sometimes it is confined to the posterior end of the list, where it may be very heavy (*H. elongata*, Figure 96: 3); sometimes it covers the larger portion of it (*H. hippoperoides*, Figure 96: 5; *H. mitchellana*, Plate 21, fig. 2). Fifth, the posterior transverse fin of most of the species of the Dolon group is characterized by a concentric striation. Sixth, in *H. josephinae* (Figure 96: 7) this list is characterized by peculiar coral-like thickenings.

Parasagittal lists have thus far not been found in this genus.

The *flagellar pore* is a rounded or slightly elongated opening of moderate to rather small size, located to the right in the transverse furrow, *i.e.*, on the right valve, at or slightly behind the posterior cingular list; its maximum diameter is about 3 μ. There are no records of pores of the kind found in Phalacroma (Plate 3, fig. 1, 2, of *P. pulchrum* and *P. giganteum*) on the ventral side of the left valve, near the sagittal suture, and just in front of the anterior cingular list.

The *longitudinal flagellum* has not been recorded as yet. The *transverse flagellum* has been observed in one species only, viz., in *Histioneis mitchellana* (Plate 21, fig. 2). In this species it is short, undulating, arises in the flagellar pore, and encircles the narrow base of the anterior cingular list from the right around to the left. The last peculiarity is unquestionably due to a dislocation brought about when the specimen was killed in the preserving fluid (formalin), since in all other known cases this flagellum encircles the body from the left around to the right and since it, on fixation, contracts into a close spiral which is thrown into various positions out of the normal one in the girdle.

In most of the primitive species and in the members of the Remora and Biremis groups, the *thecal wall* is areolate or faintly reticulate as well as porulate. The meshes of the reticulation always are fairly small, subequal, and rounded

to angular. In some of these forms nearly every mesh or areole has a central pore (*Histioneis carinata*, Plate **21**, fig. 8); but in others (*H. paulseni*, Plate **20**, fig. 1; *H. inclinata*, Plate **22**, fig. 5) the number of pores is decidedly less than the number of meshes or areoles. In *H. inornata*, *H. reginella*, and *H. panaria*, and in all the members of the highly differentiated species of the LONGICOLLIS, PULCHRA, and DOLON groups, on the other hand, the thecal wall is porulate but lacks every indication of reticulation and areolation. In these species, too, the number of pores is decidedly variable. In some (*e.g.*, *H. striata*, Plate **20**, fig. 6) it is very small, in others (*e.g.*, *H. josephinae*, Plate **22**, fig. 1, 2) large. When a great number is present, there is usually a close-set row on either side of the posterior cingular list and of the sagittal suture, as well as scattered pores. Originally the theca probably was areolate and porulate. In some species pores have not been observed, but they probably are always present.

Very little is known about the *protoplasmic contents*. The *nucleus*, which has a moniliform chromatin reticulum, may be small, rounded, and located near the center of the body (Plate **22**, fig. 6); or it may be fairly large, ovoidal, and located posterodorsally (Schütt, 1895, pl. 5, fig. 23). At least one large *pusule* opens into the flagellar pore (Plate **22**, fig. 6). *Chromatophores* appear always to be absent.

Ovoidal or round *phaeosomes*, of small or medium sizes, are frequently found in the girdle. Sometimes they occur in very large numbers (*H. highleyi*, Figure 98: 1). Their color is green, pale olivaceous, or yellowish green. The enlarged girdle serves throughout as a generalized phaeosome chamber in this genus.

The *length of the body* ranges within the genus from 13.3 μ (*Histioneis inornata*) to 88.7 μ (*H. biremis*); in our material the maximum length is 66.5 μ (*H. highleyi*).

Distribution: — The species of Histioneis may be compared in some particulars with the orchids and the hummingbirds; they are very multiform, aberrant, and beautiful in shape, brilliant in colors, exceedingly rare, and reach their highest development in the tropics. Like the species of Ornithocercus, Parahistioneis, Amphisolenia, and Triposolenia, they contribute to the striking contrast between the plankton of the warm equatorial regions and that of the cold polar seas. The genus is marine, of circumequatorial distribution, and appears to avoid coastal waters even more than does any other genus of Dinophysoidae. Most of its species seem to be restricted to tropical and subtropical seas; only a few of them occur in the Mediterranean. In the Atlantic Ocean as well as in the Pacific, its northern limit appears to be about lat. 35° N.; the limits of its southern extension are unknown not only in the Atlantic and Indian Oceans but also in the Pacific,

since it was found by us at our southernmost station. The general distribution of the genus as a whole as well as of the individual species is very uncertain, due to the scarcity of distributional data available at the present time. This paucity of data undoubtedly arises from the extreme rarity of these highly specialized organisms, and in part from their small size.

Our knowledge of the vertical distribution of the genus is also very incomplete. Nearly all of the records of this genus published at the present writing are from surface hauls. No records based on catches made with closing nets have been published as yet. Every one of the species is very rare.

Representatives of Histioneis were found at thirty-eight (29.9%) of the 127 stations of the Expedition from which dinoflagellates were recorded. These thirty-eight stations are distributed over the whole area covered by the Expedition in the following manner (Plate 30): —

0 (0.0%) out of the 4 stations in the California Current
2 (15.4%) out of the 13 stations in the Mexican Current
2 (11.8%) out of the 17 stations in the Panamic Area
0 (0.0%) out of the 27 stations in the Peruvian Current
5 (50.0%) out of the 10 stations in the Easter Island Eddy
0 (0.0%) out of the 4 stations in the Galapagos Eddy
27 (60.0%) out of the 45 stations in the South Equatorial Drift
2 (66.7%) out of the 3 stations in the South Equatorial Current
0 (0.0%) out of the 2 stations in the Equatorial Counter Current
0 (0.0%) out of the 2 stations in the North Equatorial Current

The numbers of these thirty-eight stations are as follows: — 4590, 4604 (Mexican Current); 4619, 4623 (Panamic Area); 4689, 4691, 4695, 4697, 4699 (Easter Island Eddy); 4679, 4680, 4681, 4683, 4685, 4701, 4705, 4707, 4709, 4711, 4717, 4719, 4720, 4721, 4722, 4724, 4725, 4728, 4730, 4732, 4733, 4734, 4736, 4737, 4739, 4740, 4741 (South Equatorial Drift); 4742, 4743 (South Equatorial Current).

At twenty-eight of these thirty-eight stations Histioneis was taken in vertical hauls and at ten in surface hauls. Most of the vertical hauls are from 300–0 fathoms, some are from 800 and 100–0 fathoms. Vertical hauls were made at only sixty-eight out of the 127 stations. The genus was thus found at 41.2% of the stations at which vertical hauls were made.

Disregarding the stations at which surface catches only were made, the record stations are distributed over the area covered by the Expedition in the following manner: —

0 (0.0%) out of the 4 stations in the California Current
1 (20.0%) out of the 5 stations in the Mexican Current
0 (0.0%) out of the 6 stations in the Panamic Area

0 (0.0%) out of the 22 stations in the Peruvian Current
5 (100.0%) out of the 5 stations in the Easter Island Eddy
0 (0.0%) out of the 2 stations in the Galapagos Eddy
21 (91.3%) out of the 23 stations in the South Equatorial Drift
1 (100.0%) out of the 1 station in the South Equatorial Current

There were no vertical hauls made in the Equatorial Counter Current and in the North Equatorial Current.

The numbers of these twenty-eight vertical stations are as follows: — 4590 (Mexican Current); 4689, 4691, 4695, 4697, 4699 (Easter Island Eddy); 4679, 4681, 4683, 4685, 4701, 4705, 4707, 4709, 4711, 4717, 4719, 4721, 4722, 4724, 4730, 4732, 4734, 4736, 4737, 4739, 4740 (South Equatorial Drift); 4742 (South Equatorial Current).

Surface catches and stomachs of Salpa taken in surface waters (81 surface catches and 24 samples of Salpa stomachs) were examined from eighty-two stations. As previously mentioned, the genus was taken at ten surface stations, *i.e.*, at 12.2% of all the surface stations. Taking into consideration the surface stations only, these ten record stations are distributed in the following manner: —

0 (0.0%) out of the 4 stations in the California Current
1 (11.1%) out of the 9 stations in the Mexican Current
2 (15.4%) out of the 13 stations in the Panamic Area
0 (0.0%) out of the 20 stations in the Peruvian Current
0 (0.0%) out of the 5 stations in the Easter Island Eddy
0 (0.0%) out of the 2 stations in the Galapagos Eddy
6 (26.1%) out of the 23 stations in the South Equatorial Drift
1 (50.0%) out of the 2 stations in the South Equatorial Current
0 (0.0%) out of the 2 stations in the Equatorial Counter Current
0 (0.0%) out of the 2 stations in the North Equatorial Current

The numbers of these ten surface stations are as follows: — 4604 (Mexican Current); 4619, 4623 (Panamic Area); 4680, 4720, 4725, 4728, 4733, 4741 (South Equatorial Drift); 4743 (South Equatorial Current).

As will be seen from these tables, the distribution of Histioneis in the area examined by the Expedition is charactized by the following outstanding facts: — (*1*) the genus is completely absent from the California and Peruvian Currents, two currents of temperate origin; (*2*) it is also absent from the Galapagos Eddy, which is under the direct influence of the Peruvian Current, and from the Equatorial Counter Current and the North Equatorial Current; (*3*) it is very rare in the Mexican Current and the Panamic Area, for in these regions only four out of the twenty-four species of this genus were found, and there are only four record stations out of thirty stations; (*4*) in the Easter Island Eddy and the South

Equatorial Current, on the other hand, the genus occurred at all the vertical stations, and in the South Equatorial Drift it was found at no less than twenty-one (91.3%) out of the twenty-three vertical stations.

These facts indicate that the genus Histioneis is limited in its distribution largely by the temperature, and that its species are stenothermal, warm-water forms. The fact that most of these species avoid the coasts suggests that we are dealing with stenohaline organisms limited to high and uniform salinities. The causes of the rarity of this genus in the Mexican Current and in the Panamic Area are obscure. It may be that they should be sought in the unusually turbulent current conditions of these regions (compare the distributions of *Ornithocercus heteroporus*, *O. splendidus*, and *O. carolinae*).

There are ninety-four records of species of Histioneis from vertical catches. Out of these ninety-four records, five (5.5%; Stations 4590, 4730 [two records], 4732 [two records]) showed a frequency of 1%; the remaining eighty-nine (94.5%) showed a frequency of less than 1%. There are seventeen records of species of this genus from surface catches. Out of these seventeen records, one (5.9%; Station 4619) showed a frequency of 4%; the remaining sixteen (94.1%) showed less than 1% or did not have the frequency established. The average frequency of the individual species of this genus is decidedly less than in any other genus of Dinophysoidae except in Parahistioneis.

Coincident occurrence of different species of Histioneis in catches from 300 (800, 100)–0 fathoms is recorded at the following of the twenty-eight stations mentioned above: — eight species occurred coincidently at one station (3.6%; Station 4724); seven species at one station (3.6%; Station 4730); six species at four stations (21.4%; Stations 4699, 4701, 4722, 4734); five species at one station (3.6%; Station 4737); four species at three stations (10.7%; Stations 4711, 4732, 4740); three species at six stations (21.4%; Stations 4681, 4691, 4695, 4697, 4705, 4742); two species at eight stations (28.6%; Stations 4590, 4679, 4685, 4689, 4709, 4721, 4736, 4739). Coincident occurrence of different species of this genus in surface catches is recorded at the following of the ten surface stations mentioned above: — four species occurred coincidently at one station (10.0%; Station 4720); three species at one station (10.0%; Station 4733); two species at two stations (20.0%; Stations 4725, 4741).

Although the species of Histioneis appear to be well adapted to flotation, they are very rare in surface hauls. During the Expedition only two out of our twenty-four record species were found free-living in surface waters; these two species were *H. costata* and *H. dolon*. The remaining surface records refer to

specimens found in the stomachs of Salpa taken near the surface. In Salpa stomachs the following species were found: — *H. biremis*, *H. costata*, *H. dolon*, *H. gubernans*, *H. hyalina*, *H. inclinata*, *H. inornata*, *H. longicollis*, *H. navicula*, *H. pacifica*, and *H. striata*. These facts suggest that Histioneis is not adapted to the highly illumined water near the surface of the sea but may be brought there by Salpa feeding at lower levels.

Out of our twenty-four record species not less than seventeen have never been found outside of the area investigated by the Expedition. It is not probable that these species are limited to this area, nor that the eastern tropical Pacific is richer in species of this genus than other tropical seas. This fact indicates how incomplete is our knowledge in this field. It should be remembered that most writers who have treated Histioneis, such as Murray and Whitting (1899), have had only surface catches at their disposal, and that most of the species of this genus appear to avoid surface waters.

Historical Discussion and Systematics

Stein (1883, p. 25), who established Histioneis, gave no diagnosis but confined himself to some general remarks about the organization and systematic position of this genus and to the representation of five species, viz., *H. biremis*, *H. crateriformis*, *H. cymbalaria*, *H. megalocopa*, and *H. remora*. Of the three generic diagnoses later published by Bütschli (1885, p. 1010), Delage and Hérouard (1896, p. 386), and Schütt (1896, p. 29), the one by Schütt is by far the best and most nearly complete. No extensive description and discussion of the morphology of this genus have appeared hitherto. The amount of original observations available is very small, due to the extreme scarcity of the species and to the nearly complete limitation of the genus to tropical and subtropical seas.

Besides the five specific names of Histioneis introduced by Stein (1883), the following specific and subspecific names of this genus occur in the literature: —

H. gubernans Schütt (1895)
H. dentata Murray & Whitting (1899)
H. dolon Murray & Whitting (1899)
H. francescae Murray & Whitting (1899)
H. helenae Murray & Whitting (1899)
H. highleyi Murray & Whitting (1899)
H. magnifica Murray & Whitting (1899)
H. milneri Murray & Whitting (1899)
H. mitchellana Murray & Whitting (1899)
H. para Murray & Whitting (1899)
H. splendida Murray & Whitting (1899)
H. quadrata Lemmermann (1901a)
H. steini Lemmermann (1901a)
H. magnifica var. *quadrata* Entz (1902b)
H. magnifica var. *steini* Entz (1902b)
H. mitchelliana Schröder (1906a)
H. carinata Kofoid (1907a)
H. garretti Kofoid (1907a)
H. josephinae Kofoid (1907a)
H. longicollis Kofoid (1907a)
H. navicula Kofoid (1907a)
H. paulseni Kofoid (1907a)
H. pulchra Kofoid (1907a)
H. reticulata Kofoid (1907a)
H. costata Kofoid & Michener (1911)
H. diomedeae Kofoid & Michener (1911)
H. elongata Kofoid & Michener (1911)
H. hippoperoides Kofoid & Michener (1911)

H. hyalina Kofoid & Michener (1911)
H. inclinata Kofoid & Michener (1911)
H. inornata Kofoid & Michener (1911)
H. karsteni Kofoid & Michener (1911)
H. panda Kofoid & Michener (1911)
H. reginella Kofoid & Michener (1911)
H. rotundata Kofoid & Michener (1911)
H. striata Kofoid & Michener (1911)
H. kofoidi Forti & Issel (1925)

A representative of this genus was figured also by Cleve (1902b) under the name of *Dinophysis intermedia*. In the present paper we have established two new species, viz., *Histioneis pacifica* and *H. panaria*.

Of these species and subspecies the following are referable to the genus Ornithocercus: — *Histioneis magnifica* and *H. splendida* Murray and Whitting (1899); *H. quadrata* and *H. steini* Lemmermann (1901a); *H. magnifica* var. *quadrata* and *H. magnifica* var. *steini* Entz (1902b). The following have been assigned in the present paper to the new genus Parahistioneis: — *H. crateriformis* Stein (1883), *H. dentata* Murray and Whitting (1899), *H. diomedeae* Kofoid and Michener (1911), *H. francescae* Murray and Whitting (1899), *H. garretti* Kofoid (1907a), *H. karsteni* Kofoid and Michener (1911), *H. para* Murray and Whitting (1899), *H. reticulata* Kofoid (1907a), *H. rotundata* Kofoid and Michener (1911). *H. mitchelliana* Schröder (1906a) is a *lapsus pennae* for *H. mitchellana*. *Dinophysis intermedia* Cleve (1902b) is too inadequately figured for certainty of specific allocation but appears to be referable to *Histioneis highleyi* Murray and Whitting (1899). *H. cymbalaria* Stein (1883) is a valid but heterogeneous species (see *H. mitchellana*, the section on comparisons). See also *H. elongata*, the section on comparisons.

We have therefore at the present writing twenty-eight presumably valid species of *Histioneis*, viz.: —

H. biremis Stein (1883)
H. carinata Kofoid (1907a)
H. costata Kofoid & Michener (1911)
H. cymbalaria Stein (1883)
H. dolon Murray & Whitting (1899)
H. elongata Kofoid & Michener (1911)
H. gubernans Schütt (1895)
H. helenae Murray & Whitting (1899)
H. highleyi Murray & Whitting (1899)
H. hippoperoides Kofoid & Michener (1911)
H. hyalina Kofoid & Michener (1911)
H. inclinata Kofoid & Michener (1911)
H. inornata Kofoid & Michener (1911)
H. josephinae Kofoid (1907a)
H. kofoidi Forti & Issel (1925)
H. longicollis Kofoid (1907a)
H. megalocopa Stein (1883)
H. milneri Murray & Whitting (1899)
H. mitchellana Murray & Whitting (1899)
H. navicula Kofoid (1907a)
H. pacifica, sp. nov.
H. panaria, sp. nov.
H. panda Kofoid & Michener (1911)
H. paulseni Kofoid (1907a)
H. pulchra Kofoid (1907a)
H. reginella Kofoid & Michener (1911)
H. remora Stein (1883)
H. striata Kofoid & Michener (1911)

All the descriptions of species published hitherto are very incomplete; those by Kofoid (1907a) and Kofoid and Michener (1911) are preliminary and based on the same material as those of the present paper. No subdivision of this genus has been attempted as yet. Bütschli (1885, p. 943) discussed briefly the organization

of this genus, and Schütt (1895, p. 19, 114, 116) contributed a few observations on the morphology.

Data on the distribution of this genus are to be found in the following papers, not specifying those previously mentioned in this section: — Cleve (1901a), Daday (1888), Faria and Cunha (1917), Hensen (1911), Jörgensen (1923), Karsten (1907), Lemmermann (1899a, 1901a), Lohmann (1908), Okamura (1912), Ostenfeld and Schmidt (1901), Pavillard (1916), Schröder (1900a, 1906b), Zacharias (1906). Of these investigators only Okamura (1912) and Jörgensen (1923) give original figures by means of which their determinations may be checked.

References to Histioneis or minor contributions to our knowledge of this genus occur also in the following papers: — Balbiani (1884c), Bergh (1884), Calkins (1902), Chun (1886), Gadeceau (1909), Goldschmidt (1907), Hensen (1891), Lindemann (1924), Rudmose Brown (1903), Steuer (1910), Wallengren and Hennig (1911), Walther (1893), Willey and Hickson (1909). Ostenfeld and Schmidt (1901, p. 173) and Steuer (1910, p. 478) wrote Histoneis instead of Histioneis.

Adaptive and Systematic Value of the Characters. Principles used in the Description of the Species

Histioneis occurs almost exclusively in the tropical and subtropical seas, but it is less frequent, relatively, in the surface waters of these regions than is Ornithocercus; its optimum habitat appears to be the lower rather than the upper strata of photosynthesis. In these deeper strata the temperature is decidedly lower than near the surface, and the buoyancy is correspondingly higher. As an example of the decrease in the temperature toward the depth the following readings from one of the tropical stations of the Expedition may be given. At Station 4736 the temperatures at the surface, at 25, 50, 100, 200, and at 300 fathoms were as follows: — 81.1°, 79.6°, 74.7°, 71.7°, 55.4°, and 44.1°. In spite of this fact we find within Histioneis more extreme and beautiful examples of adaptations to flotation than in Ornithocercus or in any other genus of the tribe Dinophysoidae. It should be mentioned in this connection that, judging by their organization, the species of Histioneis are even less active swimmers than the members of Ornithocercus (with regard to the size of the transverse flagellum, see Plate 21, fig. 2).

The adaptations to flotation and to progressive spiral movement found in Histioneis are largely the same as in Ornithocercus, as follows: — (*1*) The specific gravity is relatively low; it probably is but slightly higher than that of the surrounding water. The low specific gravity is due to three different factors. First, the chamber enclosed by the girdle is always very large. In the evolutionary

series, *Histioneis elongata* — *H. carinata* — *H. navicula* (Plate 22, fig. 7; Plate 21, fig. 8, 6), it becomes progressively larger, and in some species, *e.g.*, in *H. mitchellana*, *H. pulchra*, and *H. panda* (Plate 21, fig. 2, 7; Figure 95: 9), it is even much larger than the theca. In no other genus of this tribe does this chamber attain a size even approaching that in the last three species. Since this chamber usually contains but few, if any, phaeosomes (Plate 21, fig. 6, 7, 8) and it thus is filled largely with water, its development increases the volume of the organism as a whole, without causing a corresponding increase in the absolute weight. Second, the protoplasm contains fairly large pusules and inclusions of low specific gravity, such as fats and oils. Third, the theca (body) is usually small, when compared with the size of the whole organism. It is true that in the primitive species of this genus, such as *H. paulseni*, *H. costata*, and *H. inclinata* (Figure 95: 8, 4, 13), it still is fairly large; but, on the other hand, among the higher members it becomes, generally speaking, progressively smaller and in the most complex ones, for instance in *H. pulchra*, *H. mitchellana*, *H. dolon*, and *H. josephinae* (Figure 96: 2, 4, 6, 7), it is very small. (*2*) The body is small not only when compared with the whole organism, but also when compared with the body of the species in most of the other genera of this tribe. The largest body of any of the specimens of Histioneis found in the material of the Expedition was 66.5 μ long; and in the great majority of the species of this genus its length is less than 30 μ. The total length of our largest specimen (belonging to *Histioneis mitchellana*) exceeded but slightly the length of the body of *Phalacroma giganteum*, in spite of the fact that its cingular lists and left sulcal list were very large (Figure 96: 4). (*3*) The large cingular lists also increase the surface of resistance, whenever the organism rests on one of its lateral faces. On the other hand, these lists probably do not function as parachutes (as they do in Ornithocercus) when the organism has an upright position, since the posterior of them (which surrounds the anterior) has an anterior inclination of about 90° (Figure 95: 4–8) or is even somewhat contracted anteriorly (Figure 95: 1, 11). Exceptions to the last rule are *Histioneis reginella*, *H. panaria*, and *H. panda* (Plate 20, fig. 11; Figure 85: 1, 8) and other species in which the posterior cingular list has developed more or less large, well-balanced lateral pouches. (*4*) In a few species (*H. inornata* and *H. inclinata;* Figure 95: 10, 13) the left sulcal list is comparatively small and simple. However, this list is usually large; and in several species it is not only of extraordinary size, but also more or less complex, being furnished with one or more accessory fins. When only one accessory fin is developed, this is always posterodorsal and transverse in position; its size may be moderate (*H. milneri*, *H. helenae;* Murray and Whitting,

1899, pl. 33, fig. 1b, 2b) or very large (*H. dolon*, Figure 96: 6). More than one accessory fin is found in one species only, viz., *H. josephinae* (Plate 22, fig. 1–3). This species is by far the most complex and beautiful of all the known members of Dinophysoidae, and it represents the highest degree of adaptation to flotation in this tribe. Whether small or large, simple or complex, this list, of course, increases the surface of resistance whenever the organism is turned upon one of its lateral faces, and its asymmetry causes the organism, when in this position, to sink in a descending spiral or zigzag line. It also acts as a stabilizing rudder and keel in the progressive movement, and this is probably its principal function when small and simple. Furthermore, the fact that its dorsal or ventral margin or the entire list is recurved should be related to the spiral mode of swimming (Plate 21, fig. 1, 4, 6; Plate 20, fig. 9, 11). It should also be observed that this fin has a posterodorsal transverse fin or a recurved flap only in species that are characterized by having the body more or less decidedly higher and heavier dorsally than ventrally (Figure 95: 5, 6, 7, 2, 4). This suggests that these structures function also as organs of balance. Finally, we wish to point out that the accessory fins in *H. josephinae* also increase the surface of resistance when the organism is suspended in an upright position.

The ribs and reticulations of the lists increase the surface of friction. On the other hand, it is a fact worth mentioning in this connection that while the theca is reticulate or areolate in some of the more or less primitive species (Plate 20, fig. 1, 3, 7), it is smooth or almost so in all the highly differentiated members of this genus.

We do not know as yet whether or not the water contained in the girdle passes out posteriorly. It appears probable, however, that it leaves posteroventrally, entering the canal formed by the right sulcal list (Plate 20, fig. 7). This canal opens posteriorly at the place where the left sulcal list crosses over from the left to the right valve. If the water passes through this canal, then it hits the left sulcal list obliquely, thus causing the organism to rotate.

The significance of the profound changes in the shape of the body must be considered as largely uncertain. The extreme dorsoventral elongation is, of course, connected with the increase in the volume of the girdle. At least in some species the asymmetry may be related to the spiral swimming. In other species (*e.g., Histioneis pulchra, H. hippoperoides, H. dolon;* Figure 96: 2, 5, 6) the shifting of the center of gravity toward the dorsal side may counterbalance the extreme development of the left sulcal list.

The large chamber formed by the girdle functions, just as in Ornithocercus,

not only to decrease the specific gravity but also as a container for the phaeosomes.

All the external characters have been used in our descriptions and separations of the species of Histioneis. None has been especially emphasized, since all of them are subject to profound changes within the genus. The size, shape, and structure of the body, of the cingular lists, and of the sulcal lists, all furnish characters of great taxonomic importance. The variability of the individual features within the species is, unfortunately, but slightly known, since of most of the species only one or a few specimens have been recorded and figured. However, the rather pronounced constancy of the few species of which a comparatively large number of specimens have been found indicates that the members of this genus are much less variable than those of related genera, *e.g.*, Ornithocercus.

All characteristics given in the diagnoses and descriptions refer to specimens in lateral view, if not otherwise stated. If in the diagnoses there are no statements to the contrary, the posterior cingular list lacks structural differentiation except the dorsal and ventral ribs next to the sagittal suture, the cross-rib, and sometimes a few ribs or an indication of reticulation dorsally and ventrally in the frill, and the left sulcal list has only the three main ribs. Furthermore, the posterior cingular list has a fairly narrow frill and is not or but slightly bulging, and the margins of the left sulcal list are not recurved. The methods of measuring lengths, angles, and proportions as well as the terminology utilized in the present paper are shown in Figure 94. It should be added that when there is a statement that the fission rib is straight, it refers to the posterior as well as to the anterior member of this rib.

Subdivisions. Relationships among the Species

Histioneis exhibits a wider range of structural differentiation than any other genus of Dinophysoidae. While some of its twenty-eight known species are comparatively simple, others are very complex and bizarre, representing the culmination of the evolutionary processes within this tribe. The genus offers striking examples of one of the most interesting and significant features of the processes of evolution, viz., the independent appearance in different evolutionary lines of characteristics that were inherent in but not morphologically expressed by the simpler common ancestors. These interwoven "tendencies," resulting in convergencies, form the most serious obstacle to a natural subdivision of this genus. The subdivision presented below, which is the first one to be attempted as yet, is based largely on the behavior of the posterior fission rib of the left sulcal list, on

the presence or absence of a transverse fin on the posterior main rib of this list, on the structural differentiation of the frill of the posterior cingular list, and to a less extent on the shape of the body and of the anterior cingular list.

With the exception of the first group, the groups established below appear to represent progressive evolutionary series. The following characters are especially subject to evolutionary changes within these groups: — the size of the body, the dorsoventral elongation of the body, the size of the organs of flotation, the structure of the posterior cingular and the left sulcal lists, and the size of the phaeosome chamber. A striking feature of these evolutionary processes is the independence of the individual characteristics.

1. Primitive species and highly differentiated species of somewhat isolated positions: — *H. costata, H. paulseni, H. inclinata, H. inornata, H. reginella,* and *H. panaria* (Figure 95: 4, 8, 13, 10, 2, 6).

2. Remora group: — *H. remora, H. elongata, H. carinata,* and *H. navicula* (Stein, 1883, pl. 22, fig. 11; Figure 96: 3; Figure 95: 1, 3).

3. Biremis group: — *H. biremis* and *H. highleyi* (Figure 95: 11, 14).

4. Longicollis group: — *H. kofoidi, H. longicollis, H. hyalina,* and *H. pacifica* (Forti and Issel, 1925, fig. 1; Figure 95: 7, 5, 12).

5. Pulchra group: — *H. gubernans, H. striata, H. pulchra, H. mitchellana, H. cymbalaria,* and *H. panda* (Schütt, 1895, pl. 5, fig. 23; Figure 96: 1, 2, 4; Stein, 1883, pl. 22, fig. 7; Figure 95: 9).

6. Dolon group: — *H. helenae, H. milneri, H. dolon, H. hippoperoides, H. megalocopa,* and *H. josephinae* (Murray and Whitting, 1899, pl. 33, fig. 1, 2; Figure 96: 6, 5; Stein, 1883, pl. 22, fig. 12; Figure 96: 7).

1. Primitive species and highly differentiated species of somewhat isolated positions. This group, as shown by its caption, is made up of two subgroups: (*a*) primitive species and (*b*) highly differentiated species of isolated positions. *Histioneis costata, H. paulseni, H. inclinata,* and *H. inornata* belong to subgroup *a; H. reginella* and *H. panaria* to subgroup *b*. Of the four species of subgroup *a*, the first two are structurally closer to each other than to either of the last two, which in their turn show rather pronounced similarities. The two species of subgroup *b* exhibit rather striking similarities in the cingular lists. They appear not to be connected with any of the remaining five groups but to be derived from an evolutionary line rooted among the primitive members of the genus.

Histioneis costata (Figure 95: 4): — This species is one of the most primitive members of this genus. The following of its characters are more or less primitive: the body is subrotund in lateral outline; the transverse furrow is almost flat and

has a rather pronounced dorsoposterior inclination; the thecal wall is areolated; the anterior cingular list has but a short stalk and its anterior opening is very wide; the posterior cingular list is relatively low and simple in structure, its frill being without ribs and reticulation; and the left sulcal list is simple in shape and structure, its fission rib is straight, and its posterior main rib lacks a transverse fin. On the other hand, this species is fairly advanced in size (compare, for instance, *H. inclinata* and *H. inornata;* Figure 95: 10, 13), and its hypotheca expresses, although but slightly, a tendency to elongate dorsoventrally. The angularity of the posteroventral margin of the left sulcal list is a peculiarity not occurring in any other species of this genus. It suggests relationship with *Ornithocercus formosus* (Plate 17, fig. 5) and is probably the morphological expression of genetic tendencies inherent in the ancestors of the genera Ornithocercus and Histioneis.

Histioneis paulseni (Figure 95: 8): — This species, too, is near the base of the evolutionary scale of Histioneis. In the shape and structure of the anterior cingular list it is more primitive than any other species of this genus; it is, indeed, the only species in which this list is not stalked. Other more or less primitive features are as follows: the transverse furrow is but gently concave and has a decided dorsoposterior inclination; the thecal wall is areolate; the posterior cingular list is relatively low and lacks structural differentiation except the dorsal and ventral ribs and the simple cross-rib; and the left sulcal list is simple in shape and structure, its fission rib is straight, and its posterior main rib lacks a transverse fin. In regard to the size and structure of the body, the differentiation of the posterior cingular list, and the size of the left sulcal list, *H. paulseni* has reached about the same evolutionary stage as *H. costata.* On the other hand, the tendency of the hypotheca to elongate dorsoventrally, which is but slightly materialized in the latter species, is very pronounced in the former.

Histioneis inclinata (Figure 95: 13): — This species is characterized especially by the small size and simple shape of its left sulcal list. The portion of this list which is behind the fission rib is very short and decidedly smaller than the anterior portion; while in other species it is larger, usually even strikingly so. As we have suggested in connection with our treatment of this species, this appears to be a representative of an evolutionary branch which split off at a fairly early stage in the phylogenetic differentiation of this genus and in which either the increase in size of the posterior portion of the left sulcal list was inhibited, or in which this portion became subject to reduction. The comparatively large size of this list is *Histioneis costata* and *H. paulseni* as well as in the primitive members of the related genera Ornithocercus and Parahistioneis appears to support the

latter of these alternatives. *Histioneis inclinata* is more primitive than *H. costata* and *H. paulseni* in the small size of its body (length 17.2 μ as compared with 26.4–29.0 μ) and in the subcircular and subsymmetrical lateral outline of its hypotheca. In the shape of the transverse furrow and in the structure and relative size of the posterior cingular list, this species has reached the same evolutionary level as *H. costata*. The thecal wall is still areolate, but the areolation shows a pronounced tendency to disappear, as it has done in most of the higher members of the genus. The anterior cingular list is somewhat more advanced in shape than that of *H. costata*, its stalk being better differentiated. The structure of this list recalls *H. carinata*.

Histioneis inornata (Figure 95: 10): — This species occupies a somewhat isolated position near the base of the evolutionary scale of this genus. The following features are more or less primitive: the body is very small; the hypotheca is subcircular and subsymmetrical in lateral outline; the posterior cingular list is simple in structure, having only the dorsal and ventral ribs and the simple cross-rib; and the left sulcal list is simple in shape and structure and its fission rib is straight and subhorizontal. Whether the small size of the left sulcal list is primitive or secondary cannot be decided (see above, the discussion of *H. inclinata*). The subhorizontal position of the transverse furrow, the almost complete lack of structural differentiation in the thecal wall, the very long stalk and narrow anterior opening of the anterior cingular list, and the relatively large and bulging posterior cingular list are all advanced features that set *H. inornata* off rather markedly from the other primitive members of the genus. This species approaches *H. inclinata* in the small size of the body, in the subcircular shape of the hypotheca in lateral view, in the small size of the left sulcal list, and in the straight and subhorizontal fission rib of this list. Most of these similarities, however, are primitive, and so they do not of necessity indicate that these two species are members of the same evolutionary line. We consider these species structurally more closely related to each other than to any other members of this genus and at the same time as representatives of different branches, *H. inornata* being in several respects structurally farther removed from the common ancestral type. *H. inornata* recalls *H. striata* (Figure 96: 1) in the small size and subrotund, anteriorly truncate shape of the body, in the slight structural differentiation of the thecal wall, and in the long stalk and narrow anterior opening of the anterior cingular list. It differs very markedly from this species in having the posterior cingular list bulging and simple in structure, and in its small, narrow, and structurally simple left sulcal list. In spite of these differences, it probably belongs to the same

line of evolution as the mentioned species, in which case it would present a small side branch of the evolutionary line that led to the development of the PULCHRA group, in which the increase in size and structural complexity of the posterior portion of the left sulcal list was inhibited. Note in this connection the difference in the shape of the anterior cingular list between *H. inornata* and *H. gubernans* (Schütt, 1895, pl. 5, fig. 23), the most primitive member of the PULCHRA group.

H. reginella (Figure 95: 2): — The position of this species in the natural system of Histioneis is uncertain and isolated. A few of its features are still more or less primitive, but in most respects it is advanced or even very aberrant. The subcircular shape of the hypotheca in lateral outline, the great width of the anterior opening of the anterior cingular list, and the subhorizontal position of the fission rib of the left sulcal list are primitive features. On the other hand, the species is more or less advanced in the following respects: the body is fairly large; the transverse furrow is subhorizontal; the thecal wall lacks reticulation and areolation; the anterior cingular list has a rather long stalk; the posterior cingular list has large lateral pouches and its cross-rib is furnished with branches; and the left sulcal list is strikingly curved and curled and supported by accessory ribs. In the shape of the body and of the anterior cingular list, and in the ribbing of the frill of the posterior cingular list, *H. reginella* recalls *H. gubernans* (Schütt, 1895, pl. 5, fig. 23), which is in several respects the most primitive member of the PULCHRA group. However, a close relationship between *H. reginella* and the members of the PULCHRA group appears very doubtful on account of the large lateral pouches of the posterior cingular list, the curled and curved shape of the left sulcal list, and the subhorizontal position of the posterior fission rib of this list characteristic of *H. reginella*. If *H. reginella* belongs to the same evolutionary line as the species of the PULCHRA group, then it is a highly specialized member of a branch that split off at a very early stage, before the left sulcal list became prolonged posteriorly and before the posterior fission rib of this list became recurved dorsally. The marked similarity between *H. reginella* and *H. inornata* in the shape and structure of the body and in the length of the left sulcal list may possibly be indicative of a relationship of this kind. In the large lateral pouches of the posterior cingular list and in the shape and structure of the anterior cingular list, *H. reginella* resembles *H. panaria* (Figure 85: 8, 9). However, since these species differ so markedly from each other in almost every other respect, *e.g.*, in the shape of the body and of the left sulcal list, these similarities must be considered as due to convergences, and cannot be taken as indicative of close relationship.

Histioneis panaria (Figure 95: 6): — This peculiar and aberrant species oc-

cupies a very isolated and uncertain position within its genus. The following of its characteristics are more or less primitive: its anterior cingular list has a wide anterior opening; its left sulcal list is of moderate size and is simple in shape and structure; the posterior fission rib of the last-mentioned list, although decidedly deflected posteriorly, is not recurved dorsally but is almost straight. In most other respects this species is very advanced; in the shape of the body and of the posterior cingular list it has advanced even as far as the most highly differentiated members of this genus. It resembles *H. panda* (Figure 95: 9) in the sausage-like shape of its body, in the large lateral pouches of its posterior cingular list, and in the moderate size and simple shape of its left sulcal list. These similarities, however, undoubtedly are due to convergence and are not indicative of a close relationship, since *H. panda* is a highly specialized representative of the PULCHRA group, a group in which even the most primitive members are characterized by having the posterior fission rib of the left sulcal list recurved dorsally. The shape of the anterior cingular list and the large lateral pouches of the posterior cingular list in *H. panaria* recall *H. reginella*. But, again, a close relationship between these two species seems very improbable, since they differ profoundly in most other respects, especially in the shape of the body and in the shape and structure of the left sulcal list. Since *H. panda* and *H. reginella* are the only species showing more or less marked resemblances to *H. panaria*, the relationships of this species must be considered as unknown.

It is to be noted that in connection with the dorsal elongation of the body in this species we find a compensatory posterior elongation of the rudder-like left sulcal list.

2. REMORA group (Stein, 1883, pl. 22, fig. 11; Figure 96: 3; Figure 95: 1, 3). Body of varying shapes, but never characterized by a spur-like posterodorsal protuberance. Thecal wall areolate or reticulate, and furnished with pores. Anterior cingular list with moderately long to rather short stalk and wide anterior opening. Posterior cingular list with narrow frill, without lateral pouches, and almost or completely lacking structural differentiation, except the dorsal and ventral ribs and the simple cross-rib. Left sulcal list with straight fission rib and without accessory fins; its posterior main rib is branched posteriorly. The species in this group are comparatively large.

The four species of this group, which are strikingly different in habitus, form in some characters, viz., in the shape of the body and in the size of the posterior cingular list, a well-marked orthogenetic series. In *H. remora* (Stein, 1883, pl. 22, fig. 11), which is the most primitive link in this series, the body is about as deep as

long and the hypotheca is subcircular and subsymmetrical. In *H. elongata*, which is structurally very close to *H. remora*, it is decidedly asymmetrical and shows a marked tendency toward dorsoventral elongation. This tendency is materialized in *H. carinata*, which is characterized by having the hypotheca of a short canoe-shape, and reaches its highest expression in *H. navicula*, in which the hypotheca is of a long canoe-shape. The size of the posterior cingular list also increases from *H. remora* to *H. navicula;* in *H. remora* and *H. elongata* it is of a moderate size; in *H. carinata* it is decidedly larger; and in *H. navicula* it is exceptionally large and bulging. In the case of the left sulcal list, on the other hand, the conditions are reversed. This list is exceptionally long in *H. remora* and *H. elongata*, of intermediate length in *H. carinata*, and quite short in *H. navicula*. The posterior branching of the posterior main rib of this list is also simpler in *H. navicula* than in any of the other species of this group. In the structure of the theca and of the cingular lists the four species of this group do not show any distinct advancement but have remained on about the same evolutionary level as *H. costata*.

3. Biremis group (Figure 95: 11, 14). Body characterized by a spur-like posterodorsal protuberance. Thecal wall areolate and porulate. Anterior cingular list with fairly short stalk, and with wide anterior opening. Posterior cingular list with narrow frill, without lateral pouches, and lacking structural differentiation except the dorsal and ventral ribs and the simple cross-rib. Left sulcal list with straight fission rib and without accessory fins; its posterior main rib is branched posteriorly. The species of this group are very large.

The two species included in this group are quite similar and have reached about the same evolutionary stage except in the shape of the hypotheca, in the case of which *H. biremis* is the more primitive.

4. Longicollis group (Forti and Issel, 1925, fig. 1; Figure 95: 7, 5, 12). Body of simple but varying shapes; transverse furrow subhorizontal and flat or almost so. Thecal wall without reticulation and areolation, but usually porulate. Anterior cingular list with moderately to very long stalk; its anterior opening narrow to moderately wide. Posterior cingular list without lateral pouches and lacking structural differentiation except the dorsal and ventral rib and the simple cross-rib. Left sulcal list long and narrow, relatively simple in shape; showing, in some species, the incipient stages of the curling to the right of the dorsal margin; the posterior fission rib recurved to the right, usually joining the posterior main rib near the middle; disregarding the last feature, the structure of this list is usually very simple; without accessory fins. The species in this group are comparatively small.

Of the four species that are included in this group *Histioneis kofoidi* (Forti and Issel, 1925, fig. 1) is on the whole the most primitive and *H. hyalina* the most advanced. However, the species do not form a distinct orthogenetic series, but the differentiation of the individual characters has proceeded with a marked independence, as will be seen from the following examples. In *H. kofoidi* the hypotheca has retained its primitive shape, being subcircular and subsymmetrical; in *H. longicollis* it is decidedly asymmetrical and exhibits a marked tendency toward dorsoventral elongation; in *H. hyalina* and *H. pacifica* this tendency is still more emphasized, the body of these species being pyriform and bean-shaped, respectively, in lateral outline, with the long axis in the horizontal plane. In regard to the anterior cingular list, *H. pacifica* is the most primitive, the stalk of this structure being of moderate length and the anterior opening wide; *H. kofoidi* and *H. longicollis* have reached about the same evolutionary stage, having a very long stalk and an anterior opening of moderate width; *H. hyalina* is the most advanced, the stalk being very long and the anterior opening narrow. The posterior cingular list is lower, and thus in this respect more primitive, in *H. pacifica* and *H. hyalina* than in *H. kofoidi* and *H. longicollis*. In the case of the fission rib of the left sulcal list, *H. longicollis* is more primitive than the other species of this group, which in this feature have reached about the same evolutionary stage; its anterior member is comparatively short and but moderately deflected posteriorly; and its posterior member does not join the posterior main rib. On the other hand, *H. longicollis* is characterized by having the posterior main rib of this list marginal instead of submarginal as in the other species, although the latter condition is presumably the more primitive.

In *H. kofoidi* and *H. longicollis* the left sulcal list is nearly flat, which is the primitive condition; in *H. pacifica* it is somewhat spoon-shaped, but its dorsal margin is not strongly recurved to the right; in *H. hyalina* the portion of this list dorsal to the posterior main rib is strongly curled to the right, a feature emphasized and further developed in the closely related but more highly organized and specialized Pulchra group. The ribbing of the left sulcal list is about the same in *H. kofoidi*, *H. longicollis*, and *H. hyalina;* in *H. pacifica*, on the other hand, it is decidedly more complicated, approaching the condition in *H. pulchra* (Figure 96: 2). A peculiarity that the Longicollis group has in common with the Remora and Biremis groups is that the posterior cingular list has retained its structural simplicity. Even in the most primitive member of the Longicollis group the thecal wall lacks areolation and reticulation; in this respect this group thus is more advanced than the other groups just mentioned.

5. Pulchra group (Schütt, 1895, pl. 5, fig. 23; Figure 96: 1, 2, 4; Stein, 1883, pl. 22, fig. 7; Figure 95: 9). Body varying in shape; sometimes subrotund and truncate anteriorly, sometimes saddle-, canoe-, or sausage-shaped; transverse furrow gently to strongly concave, subhorizontal or more or less inclined dorso-anteriorly. Thecal wall porulate, but without areolation and reticulation. Anterior cingular list with moderately to very long stalk; its anterior opening narrow to very wide. Posterior cingular list usually (exception, *Histioneis panda*) without large lateral pouches; its frill furnished with longitudinal ribs or with reticulation. Left sulcal list usually very large; posterior fission rib recurved dorsally, joining the posterior main rib near the middle; dorsal margin usually strongly curled to the right either in its entire extent or it forms a fairly small tongue-like flap; no paired accessory fins; besides the main ribs this list has a more or less developed reticulation. The species in this group range from small to very large.

Although the six species included in this group are structurally quite different from each other, they undoubtedly belong to the same evolutionary line. The most primitive of them is *Histioneis gubernans* (Schütt, 1895, pl. 5, fig. 23). This species is characterized by the following more or less primitive features: it is very small; its hypotheca is subcircular, although somewhat asymmetrical; its transverse furrow is subhorizontal and but slightly concave; its anterior cingular list has a moderately long stalk and a very wide anterior opening; its posterior cingular list has no lateral pouches, and lacks structural differentiation except the dorsal and ventral ribs, the cross-rib, and some simple longitudinal ribs in the frill; the reticulation of its left sulcal list is still fairly undeveloped; the anterior fission rib of this list is subhorizontal, and the dorsal margin of this list is not curled to the right. The closest-known relative of *H. gubernans* is *H. striata.* These two species have reached about the same evolutionary level in the size and shape of the body, in the shape and structure of the posterior cingular list, and in the structure of the left sulcal list. *H. striata* is farther advanced in the following respects: its anterior cingular list has a long stalk and a very small anterior opening, and the dorsal margin of its left sulcal list is strongly curled to the right in its entire length. Of the remaining species, *H. pulchra* and *H. panda* occupy rather isolated positions, while *H. mitchellana* and *H. cymbalaria* (Stein, 1883, pl. 22, fig. 7) are structurally very close to each other. *H. pulchra* is in certain respects intermediate between *H. gubernans-H. striata* on the one hand, and *H. mitchellana-H. cymbalaria* on the other; in some characteristics, *e.g.*, in the shape of the body, it has reached the same evolutionary level as these. The characters in which *H. pulchra* is more or less intermediate between the two groups just men-

tioned are as follows: the frill of the posterior cingular list is fairly narrow in the middle, and its reticulation is quite incomplete and wide-meshed; the anterior fission rib of the left sulcal list has an intermediate posterior deflection; the reticulation of this list is wide-meshed, and anteriorly it is but slightly developed; although the entire dorsal margin is curled to the right, its middle portion exhibits the incipient stage of becoming differentiated into an individualized tongue-like flap. In the comparatively simple structure of the anterior cingular list, *H. pulchra* and *H. cymbalaria* have reached about the same evolutionary level, while *H. mitchellana* is farther advanced, having this list as finely reticulated as the frill of the posterior cingular list. On the other hand, *H. cymbalaria* is farther advanced than either *H. pulchra* or *H. mitchellana* in having the anterior opening of the anterior cingular list very narrow. Finally it may be mentioned that neither *H. pulchra* nor *H. cymbalaria* and *H. mitchellana* have the posterior cingular list bulging into large lateral pouches. The last member of this group, *H. panda*, is farther advanced than the others in the following respects: the body is more elongated dorsoventrally, being of a narrow sausage-shape; the anterior cingular list has a longer stalk, and its anterior opening is quite narrow; the posterior cingular list bulges out into large lateral pouches, and its very wide frill is furnished with a narrow secondary frill. On the other hand, *H. panda* is more primitive than *H. pulchra*, *H. cymbalaria*, and *H. mitchellana* in being smaller, in having the left sulcal list relatively very small, simple in structure, and characterized by the fact that the middle portion of its dorsal margin shows but the beginning stage in the development of a tongue-like appendage curled to the right. It may finally be mentioned that the cingular lists of *H. panda* are finely reticulated just as in *H. mitchellana*, but the reticulation is so weak that it is very difficult to detect.

6. Dolon group (Murray and Whitting, 1899, pl. 33, fig. 1, 2; Figure 96: 6, 5; Stein, 1883, pl. 22, fig. 12; Figure 96: 7). Body of short saddle-shape, higher dorsally than ventrally; transverse furrow moderately to strongly concave, more or less inclined dorsoanteriorly. Thecal wall porulate, but without areolation and reticulation. Anterior cingular list with long stalk; its anterior opening narrow to very wide. Posterior cingular list sometimes without lateral pouches, sometimes (*Histioneis dolon*, *H. hippoperoides*) with lateral pouches of moderate size; frill reticulate, often with a secondary frill. Left sulcal list large, usually reticulated; posterior fission rib not recurved dorsally, but runs close to anterior fission rib; posterior main rib with a transverse fin. The species of this group range from fairly large to large.

Of the six members of this group, *Histioneis josephinae* occupies a quite isolated position (see our treatment of this species, the section on comparisons), while the remaining ones are structurally, and presumably also phylogenetically, very close. The beautiful and bizarre *H. josephinae* represents without doubt the culmination of the structural differentiation within Dinophysoidae. The accessory fins along the ventral margin and along the fission rib of the left sulcal list, as well as the peculiarly ornamental coral-shaped thickenings of this list are without counterparts in the other known species of this tribe. The curvature of the body is also more extreme in this species than in the remaining five members of the DOLON group. On the other hand, *H. josephinae* is comparatively primitive in the wide anterior opening of its anterior cingular list and in having its posterior cingular list completely without lateral pouches; furthermore, its left sulcal list lacks entirely the reticulation which characterizes the other species of this group. Of the last-mentioned species, *H. helenae* and *H. milneri* (Murray and Whitting, 1899, pl. 33, fig. 1, 2) are the most primitive, since they are characterized by having only one submarginal rib along the ventral margin of the left sulcal list and by the moderate size of the transverse fin of this list. *H. dolon*, *H. hippoperoides*, and *H. megalocopa* (Stein, 1883, pl. 22, fig. 12) have two to more submarginal ribs and their transverse fin is very large. *H. helenae* and *H. milneri* have reached about the same evolutionary stage, except in the shape of the transverse fin, in which respect *H. helenae* appears to be the more primitive; it may also be mentioned that in the last-named species the reticulation in the frill of the posterior cingular list is less developed. Among these five species *H. megalocopa* is farthest advanced in having the frill of the posterior cingular list finely reticulated, while *H. hippoperoides* is farthest advanced in having the anterior opening of the anterior cingular list very narrow. *H. dolon* and *H. hippoperoides* have the posterior cingular list bulging into lateral pouches of moderate size.

With regard to the interrelationships of these groups, we are able to make but a few suggestions. The BIREMIS group probably originated from an ancestral form fairly closely resembling *Histioneis carinata* of the REMORA group. This assumption is based on the very striking similarities that exist between the members of the BIREMIS group and *H. carinata* in the shape and structure of the cingular list and of the left sulcal list, and in the structure of the body; another important fact is that in *H. biremis* the body has about the same dorsoventral elongation as in the compared species. It should be remembered, however, that some of the similarities are primitive (for an enumeration of primitive features, see the discussion given above of *H. costata* and *H. paulseni*). The LONGICOLLIS

and PULCHRA groups probably originated from a common ancestor, characterized especially by the fact that the posterior fission rib of the left sulcal list was recurved dorsally toward the middle of the posterior main rib, and by the inherent tendency for the dorsal margin of this list to curl to the right. Of the known species *H. kofoidi* of the LONGICOLLIS group appears to be structurally closest to this common ancestor. *H. gubernans* and *H. striata*, the most primitive members of the PULCHRA group, appear to represent a small evolutionary branch that split off early, has remained more or less primitive in many respects, and that is characterized by the very great width of the left sulcal list. In the other members of these two groups the left sulcal list is of a long and narrow tongue-shape, approaching the shape found in *H. kofoidi*. As previously mentioned, *H. inornata* may be looked upon as a representative of a small branch near the base of the line of evolution that led to the development of the LONGICOLLIS and PULCHRA groups. As to the origin of the DOLON group, we are still completely ignorant; but presumably this group split off at a very early stage in the evolutionary differentiation of Histioneis (see also the above treatment of *H. reginella*).

Of the "interwoven tendencies, resulting in convergences" mentioned in the introductory paragraph of this section, the following examples may be given. Dorsoventral elongation of the body has developed independently in *Histioneis panaria*, and in the REMORA, BIREMIS, LONGICOLLIS, PULCHRA, and DOLON groups; strong concavity of the transverse furrow in *H. panaria*, and in the BIREMIS, PULCHRA, and DOLON groups; long stalk and narrow anterior opening of the anterior cingular list in *H. inornata*, and in the LONGICOLLIS, PULCHRA, and DOLON groups; lateral pouches in the posterior cingular list in *H. reginella*, *H. panaria*, and in the PULCHRA and DOLON groups; a secondary frill in this list in the PULCHRA and DOLON groups; ribbing of the frill of this list in *H. reginella*, *H. panaria*, and in the PULCHRA and DOLON groups. This list, although by no means complete, is sufficient to illustrate the great difficulties that the taxonomy of this genus offers. It also shows that the arrangement suggested above, on account of these difficulties, must be regarded as tentative, and must possibly be modified and extended as our knowledge of the species of this remarkable genus is enlarged by future exploration, although, for the sake of simplicity in presentation, we have made it quite dogmatic.

Key to the Species of Histioneis

1. Posterior R_2 of left sulcal list recurved dorsally, joining R_3 or nearly so ..... 2.
1. Posterior R_2 of left sulcal list not recurved ..... 11.
2. Frill of posterior cingular list lacks structural differentiation or almost so ..... 3.
2. Frill of posterior cingular list has longitudinal ribs or reticulation ..... 6.

3. Length: depth of body, 0.85–1.00: 1 ..... 4.
3. Length: depth of body, 0.60–0.65: 1 ..... 5.
4. R_3 of left sulcal list is marginal ..... *H. longicollis* Kofoid.
4. R_3 of left sulcal list is not marginal ..... *H. kofoidi* Forti and Issel.
5. R_3 of left sulcal list extends to postmargin of list and forms reticulation posteriorly. *H. pacifica*, sp. nov.
5. R_3 of left sulcal list does not extend to postmargin of list and does not form reticulation posteriorly. *H. hyalina* Kofoid and Michener.
6. Length: depth of body, 0.80–0.95: 1 ..... 7.
6. Length: depth of body, 0.30–0.55: 1 ..... 8.
7. Anterior cingular list 7–8 times wider distally than proximally ..... *H. gubernans* Schütt.
7. Anterior cingular list about 2.5 times wider distally than proximally. *H. striata* Kofoid and Michener.
8. Posterior cingular list with large lateral pouches ..... *H. panda* Kofoid and Michener.
8. Posterior cingular list not with large lateral pouches ..... 9.
9. Left sulcal list and frill of posterior cingular list with fairly wide-meshed and partly incomplete reticulation ..... *H. pulchra* Kofoid.
9. Left sulcal list and frill of posterior cingular list with fine-meshed and complete reticulation ..... 10.
10. Anterior cingular list is 8–13 times wider distally than proximally. *H. mitchellana* Murray and Whitting.
10. Anterior cingular list about 4 times wider distally than proximally ..... *H. cymbalaria* Stein.
11. R_3 of left sulcal list with transverse fin ..... 12.
11. R_3 of left sulcal list without transverse fin ..... 17.
12. R_2 of left sulcal list with accessory fin ..... *H. josephinae* Kofoid.
12. R_2 of left sulcal list without accessory fin ..... 13.
13. Frill of posterior cingular list with rather fine-meshed reticulation ..... *H. megalocopa* Stein.
13. Frill of posterior cingular list with comparatively wide-meshed reticulation ..... 14.
14. With only one submarginal rib along ventral margin of left sulcal list; transverse fin of this list of moderate size ..... 15.
14. With two or more submarginal ribs along ventral margin of left sulcal list; transverse fin of this list large ..... 16.
15. Transverse fin of left sulcal list ovate ..... *H. helenae* Murray and Whitting.
15. Transverse fin of left sulcal list of pear-shaped outline ..... *H. milneri* Murray and Whitting.
16. Anterior cingular list 10–12 times wider distally than proximally ..... *H. dolon* Murray and Whitting.
16. Anterior cingular list 2–3 times wider distally than proximally. *H. hippoperoides* Kofoid and Michener.
17. Body has spur-like posterodorsal protuberance ..... 18.
17. Body without spur-like posterodorsal protuberance ..... 19.
18. Body Y-shaped; transverse furrow very strongly concave ..... *H. highleyi* Murray and Whitting.
18. Body not Y-shaped; transverse furrow gently concave ..... *H. biremis* Stein.
19. Posterior cingular list with large lateral pouches ..... 20.
19. Posterior cingular list without or with but slightly developed lateral pouches ..... 21.
20. Body subrotund, truncate anteriorly ..... *H. reginella* Kofoid and Michener.
20. Body sausage-shaped ..... *H. panaria*, sp. nov.
21. R_3 of left sulcal list, if present, smaller than or subequal to R_2 ..... 22.
21. R_3 of left sulcal list larger than R_2 ..... 23.
22. Portion of left sulcal list behind R_2 smaller than portion in front of this rib and has four radial ribs. *H. inclinata* Kofoid and Michener.
22. Portion of left sulcal list behind R_2 larger than portion in front of this rib and has not four radial ribs. *H. inornata* Kofoid and Michener.
23. Ventral margin of left sulcal list angular between R_2 and R_3 ..... *H. costata* Kofoid and Michener.
23. Ventral margin of left sulcal list not angular between R_2 and R_3 ..... 24.
24. Anterior cingular list funnel-shaped but not stalked ..... *H. paulseni* Kofoid.
24. Anterior cingular list distinctly stalked ..... 25.
25. Length: depth of body, 1.00–1.13: 1 ..... 26.
25. Length: depth of body, 0.50–0.65: 1 ..... 27.
26. Hypotheca subsymmetrical ..... *H. remora* Stein.
26. Hypotheca asymmetrical ..... *H. elongata* Kofoid and Michener.
27. R_3 of left sulcal list very strong, about 0.63 the depth of body ..... *H. carinata* Kofoid.
27. R_3 of left sulcal list weak, about 0.36 the depth of body ..... *H. navicula* Kofoid.

1. Primitive Species and Highly Differentiated Species of Somewhat Isolated Positions. All the six species that belong to this group have been found in the material of the Expedition. They have been treated in the following order, which is partly indicative of their relative positions in the evolutionary scale of the genus:— *Histioneis costata, H. paulseni, H. inclinata, H. inornata, H. reginella,* and *H. panaria.*

Histioneis costata Kofoid and Michener

Plate 20, fig. 3, 10. Figure 95: 4

Histioneis costata Kofoid & Michener, 1911, p. 295.

Diagnosis: — Body subrotund in lateral outline; length: depth, 0.85: 1, hypotheca subsymmetrical. Dorsally the transverse furrow is 0.46 the depth of body, four times wider than ventrally, inclined dorsoposteriorly at 20°–25°, and but slightly concave. Distance from apex to posterior cingular list 0.26 the base of this list. Anterior cingular list with short stalk; its height 0.71 the depth of body. Dorsal height of posterior cingular list 0.58 the depth of body. Left sulcal list with reticulation in front of R_2; R_2 straight, inclined posteriorly at 30°, and 0.34 the depth of body; R_3 submarginal, weak, simple, 0.62 the depth of body, located at antapex, and deflected posterodorsally at 15°; margin strikingly angular somewhat behind R_2. Theca coarsely and deeply pitted. Total length, 67.5 μ.

Eastern tropical Pacific.

Description: — This is a fairly small species, subrotund in lateral outline, deepest in or near the middle. The ratio between the length and the depth of the body is about 0.85: 1. The longitudinal axis is deflected posterodorsally at about 10°–15°.

The epitheca is about 0.24 as deep as the hypotheca, slightly convex, highest somewhat dorsally to the center, and tilted ventroposteriorly at about 20°. Dorsally the transverse furrow is about 0.46 the greatest depth of the body, about four times as wide as ventrally, inclined dorsoposteriorly at 20°–25° to the horizontal plane, and slightly concave, almost flat. The distance from the apex to the posterior cingular list is about 0.26 the base of this list. The hypotheca is subsymmetrical; its anterior margin is but slightly concave, and inclined dorsoposteriorly at about 5° to the horizontal plane; its ventral, posterior, and dorsal margins are well rounded and confluent. In dorsoventral view the body is about 1.6 times longer than wide and widest in the middle; the hypotheca has gently convex side contours and is well rounded posteriorly; the anterior portion of the body is subconical with moderately concave sides.

The anterior cingular list has a short but distinct stalk and is about 3.8 times wider distally than basally; its height is about 0.71 the greatest depth of the body, and its right side is very strikingly lower than its left, declining ventrally; on the right valve it has only three ribs, the dorsal and ventral ones of which are simple, while the middle one has two branches; on the left valve it has distally about fifteen ribs, the proximal ends of which form a reticulum; some of these fifteen ribs, however, correspond to branches of the dorsal rib (Plate **20**, fig. 10); the tips of the ribs project slightly beyond the edge of the list. These differences in the ribs on the two sides may have resulted from recent binary fission. The posterior cingular list is closed and lacks structural differentiation except the dorsal and ventral ribs, and the cross-rib; its dorsal height is about 0.58, its ventral height about 0.29 the greatest depth of the body; its frill is narrow, 0.14–0.17 the dorsal rib; and it is but slightly if at all bulging. The left sulcal list is simple in shape, and has only two ribs, the fission rib and the posterior rib. The fission rib is straight, about 0.34 the greatest depth of the body, and has a posterior inclination of about 30°. The posterior rib is weak, simple, almost straight, about 0.62 the greatest depth of the body, located at or near the antapex, deflected posterodorsally at about 15°, and submarginal, *i.e.*, the basal width of the portion of the list dorsal to this rib is only about 0.12 the length of the rib. The portion of the list in front of the fission rib is faintly reticulated; in the type specimen it is but slightly developed (following binary fission?), its ventral margin is almost straight, and its posterior width is but slightly more than half the length of the fission rib. The portion between the fission rib and the posterior rib lacks structural differentiation, and its margin forms an angle of about 60°–70° somewhat behind the fission rib. Between the fission rib and the vertex of this angle the margin is nearly straight, and between the vertex and the posterior rib it is gently concave; at the tip of the posterior rib it forms an angle of about 50°–60°, and dorsally to this rib it is almost straight. The portion of this list dorsal to the posterior rib lacks structural differentiation.

The thecal wall is coarsely and deeply pitted, with pores in some of the pits; the number of pores is decidedly less than the number of pits. The pits are of subuniform size, and on each valve about thirteen of them border the girdle posteriorly. The pits bordering the girdle posteriorly are but slightly if at all larger than the others. Phaeosomes were not seen.

The proportions of one specimen, the type, were measured.

Dimensions: — Length of body, 26.4 μ. Greatest depth of body, 31.0 μ. Total length, 67.5 μ.

Comparisons: — The description given above is based on the type specimen. Judging by the relatively small size of the anterior portion of the left sulcal list, this specimen appears to have been taken rather shortly after binary fission.

The subrotund body, and the simple shape and structure of the left sulcal list place *Histioneis costata* among the most primitive species of this genus. Still, it is a typical member of Histioneis, since the anterior cingular list is distinctly stalked and has a strikingly asymmetrical structure, and since the posterior cingular list is closed, and has a cross-rib and only two radial ribs, viz., one dorsal and one ventral. It differs from all other known species of this genus in the angularity of the posteroventral margin of the left sulcal list. Its closest relative appears to be *H. paulseni,* from which it is easily distinguished by (*1*) the relatively short anterior portion of the body, (*2*) the less shortened hypotheca, (*3*) the structure and the greater height of the anterior cingular list, and (*4*) by the fact that the left sulcal list has an angular posteroventral margin, a submarginal posterior rib, and lacks a marginal rib posteroventrally. Another close relative of this species probably is *H. crateriformis* Stein (1883, pl. 22, fig. 5, 6). This relationship is indicated by the similarities in the shape of the body and in the cingular list, and by the simple shape and structure of the left sulcal list. However, judging by Stein's (1883) figures, *H. crateriformis* lacks the cross-rib in the posterior cingular list, and thus does not belong to Histioneis *s. str.* (see the historical discussion of this genus). It should also be mentioned that *H. costata* resembles *H. inclinata* in the subrotund shape of the body, and in the shape and structure of the cingular lists. It differs very strikingly from this species in the size of the body, and in the size, shape, and structure of the left sulcal list (see also *H. inclinata,* the section on comparisons).

The two-lobed condition of the left sulcal list and the positions of the ribs of this list relative to the two lobes suggest relationship between *Histioneis costata* and *Ornithocercus formosus,* which in several respects is intermediate between Ornithocercus and Histioneis. Whether these resemblances are due to common inheritance or to convergence is, of course, a matter of conjecture, but the fact that these two species are near the bases of the evolutionary scales of these closely related genera makes it appear highly probable that the formation of the posteroventral lobe in the left sulcal list of *Histioneis costata* is the expression of a tendency inherent in the ancestral forms of these two genera but reaching its full development only in Ornithocercus.

Occurrence: — *Histioneis costata* is recorded at only two of the 127 stations. Both these stations are on the first line of the Expedition; one of them (4604) is in

the Mexican Current, the other (4619) in the Panamic Area. Both records are from surface waters; one of them (Station 4619) is from a Salpa stomach. The surface temperatures of these two stations were 84° and 79°, respectively. The frequency was 4% at Station 4619 and less than 1% at Station 4604.

This species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4604 of the Expedition which thus is the type locality.

Histioneis paulseni Kofoid

Plate 20, fig. 1, 2. Figure 95: 8

Histioneis paulseni Kofoid, 1907a, p. 204, pl. 15, fig. 94. Kofoid & Michener, 1911, p. 295. *non* Okamura, 1912, p. 21, pl. 3, fig. 53, 54.

Diagnosis: — Body depressed in lateral outline; length: depth, 0.86: 1; hypotheca of short canoe-shape, somewhat higher dorsally than ventrally. Dorsally the transverse furrow is 0.50 the depth of body, twice as wide as ventrally, inclined dorsoposteriorly at 30°–35°, and of rather pronounced concavity. Distance from apex to posterior cingular list 0.40 the base of this list. Anterior cingular list broadly funnel-shaped but not stalked; its height 0.57 the depth of body. Dorsal height of posterior cingular list 0.47 the depth of body. Left sulcal list with five very short ribs between R_2 and R_3; R_2 straight, inclined posteriorly at 30°–35°, and 0.18 the depth of body; R_3 marginal, very weak, simple, 0.75 the depth of body, located on midline, and inclined posteroventrally at 20°; ventral margin sigmoid, concave anteriorly and posteriorly and well convex in the middle, with marginal rib posteriorly; with posterior angle of 40°. Theca areolate. Total length, 67.5 μ.

Eastern tropical Pacific.

Description: — This is a fairly small, depressed species, asymmetrically conical anteriorly, broadly rounded posteriorly, and deepest near the middle. The ratio between the length and the depth of the body is about 0.86: 1. The longitudinal axis is deflected posterodorsally at about 5°–10°.

The epitheca is about 0.20 as deep as the hypotheca, slightly convex, highest somewhat dorsally to the center, and tilted posteroventrally at about 5°. Dorsally the transverse furrow is about 0.50 the greatest depth of the body, about twice as wide as ventrally, inclined dorsoposteriorly at 30°–35° to the horizontal plane, and with a rather pronounced concavity. The distance from the apex to the posterior cingular list is about 0.40 the base of this list. The hypotheca is of short canoe-shape, distinctly higher dorsally than ventrally; its anterior margin is

moderately concave, and inclined dorsoposteriorly at about 10° to the horizontal plane; its dorsal, posterior, and ventral margins are confluent; posterodorsally it is fairly strongly convex, posteroventrally rather flattened. In dorsoventral view the body is about 1.2 times longer than wide and widest in the middle; the outline of the hypotheca is subcircular; the anterior portion of the body is rounded conical, with gently concave sides.

The anterior cingular list is very broadly and rather symmetrically funnel-shaped, but not stalked, and about 4.2 times wider distally than basally; its height is about 0.57 the greatest depth of the body, and its right side is distinctly lower than the left; on the right valve it has about six ribs, all of which are simple except the dorsal one which has three branches; on the left valve the number of ribs is slightly greater; the tips of the ribs project slightly beyond the edge of the list. The posterior cingular list is closed and lacks structural differentiation except the dorsal and ventral ribs and the cross-rib; its dorsal height is about 0.47, its ventral height about 0.38 the greatest depth of the body; its frill is fairly narrow, 0.36 the dorsal rib; and it is but slightly if at all bulging. The left sulcal list is simple in shape and structure and has two main ribs and between these about five very short riblets. The fission rib is straight, about 0.18 the greatest depth of the body, and has a posterior inclination of about 30°–35°. The posterior rib is marginal, very weak, simple, but slightly convex dorsally, about 0.75 the greatest depth of the body, located on the midline, and inclined posteroventrally at about 20°. The ventral margin of this list is sigmoid, concave anteriorly and posteriorly, and quite convex in the middle. It is furnished posteriorly with a marginal rib of the same type and of about the same length as the posterior rib. The ventral and dorsal margins of this list form a posterior angle of about 40°. Except for the ribs mentioned above, this list appears to lack structural differentiation.

The thecal wall is areolate with scattered pores in some of the areoles. The areoles in the transverse furrow and those bordering the girdle posteriorly are somewhat larger than the remaining ones. On each valve about 19 areoles border the girdle posteriorly, and just behind these areoles there is a cross-row of about 16–17 pores on each valve. A moderate number of medium-sized, oval phaeosomes were found in the girdle of the type specimen.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 29.0 μ. Greatest depth of body, 33.9 μ. Total length, 67.5 μ.

Comparisons: — The description given above is based on the type specimen.

The closest-known relative of *Histioneis paulseni* probably is *H. costata*. In

the shape and structure of the anterior cingular list *H. paulseni* is the more primitive of these two species, while with regard to the shape of the body in lateral view and to the marginal position of the posterior rib of the left sulcal list it is the more advanced. In the size of the body and in the shape and structure of the posterior cingular list these species have reached the same evolutionary stage. For the distinguishing characters and for further discussion of the relationships of these two forms, see *H. costata*, the section on comparisons.

Synonymy: — This species was established by Kofoid (1907a) under the name of *Histioneis paulseni*. The specimens recorded under this name from Japanese waters by Okamura (1912, p. 21, pl. 3, fig. 53, 54) are not determined correctly but presumably belong to *H. carinata;* unfortunately, they are too incompletely figured for certainty of specific assignment.

Occurrence: — *Histioneis paulseni* is recorded at only one of the 127 stations. This station (4711) is on the fourth line of the Expedition and in the South Equatorial Drift. The depth is 300–0 fathoms, the surface temperature 75°, and the frequency less than 1% (one specimen).

This species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4711 of the Expedition, which thus is the type locality.

Histioneis inclinata Kofoid and Michener

Plate 22, fig. 5. Figure 95: 13

Histioneis inclinata Kofoid & Michener, 1911, p. 297.

Diagnosis: — Body subrotund in lateral outline; length: depth, 0.96: 1. Dorsally the transverse furrow is 0.46 the depth of body, twice as wide as ventrally, inclined dorsoposteriorly at 15°–20°, and gently concave. Distance from apex to posterior cingular list 0.25 the base of this list. Anterior cingular list with short stalk, flaring in its distal 0.6 in a wide concave funnel with twice as much dorsal as ventral extension, with no ventral notch, and slight dextroventral slope; its height 0.76 the depth of body. Dorsal height of posterior cingular list 0.50 the depth of body. Left sulcal list short, ending about midway between R_2 and midline, broadly rounded posteriorly; R_2 straight, subhorizontal, 0.26 the depth of body; portion behind R_2 with four partly anastomosing ribs. Theca finely reticulate; 17–18 meshes along girdle. Total length, 29 μ.

Eastern tropical Pacific.

Description: — This is a very small species, subrotund in lateral outline, deepest in or near the middle. The ratio between the length and the depth of

the body is about 0.96: 1. The longitudinal axis is deflected posterodorsally at about 7°.

The epitheca is about 0.15 as deep as the hypotheca, slightly convex, highest in or somewhat dorsally to the center, and tilted ventroposteriorly at about 5°–10°. Dorsally the transverse furrow is about 0.46 the greatest depth of the body, about twice as wide as ventrally, inclined dorsoposteriorly at 15°–20° to the horizontal plane, and gently concave. The distance from the apex to the posterior cingular list is about 0.25 the base of this list. The anterior margin of the hypotheca is subhorizontal and but slightly concave; the ventral, posterior, and dorsal margins are well convex and confluent; the dorsal margin is somewhat less convex posteriorly than anteriorly.

The anterior cingular list has a short but distinct stalk and is about 4.3 times wider distally than basally; it flares widely in its distal 0.6, with slightly concave sides, twice as much dorsal as ventral flare, no ventral notch, and about 30° dextroventral inclination; its height is 0.76 the greatest depth of the body, and its right side is but slightly lower than its left; on the right valve it has but two ribs, the ventral one of which has one, the dorsal three branches; its ribs on the left valve are also few; the tips of the ribs project very slightly beyond the edge of the list. The posterior cingular list is closed and lacks structural differentiation except the dorsal and ventral ribs, and the cross-rib; its dorsal height is about 0.50, its ventral height about 0.54 the greatest depth of the body; its frill is of moderate height, about 0.33 the dorsal rib; and it is but slightly or not at all bulging. The left sulcal list is simple in shape, short, ending about midway between the fission rib and the midline, and rather broadly rounded, subcircular posteriorly. The fission rib is straight, subhorizontal, and about 0.26 the greatest depth of the body. The portion of the list behind the fission rib has four partly anastomosing denticulate ribs, which converge toward the base of the fission rib; just in front of the fission rib a few anastomosing ribs also are to be found. The ventral margin of this list is gently sigmoid, concave anteriorly, and convex posteriorly.

The thecal wall is characterized by a fine reticulum, the meshes of which become more and more difficult to distinguish toward the sagittal suture; most of the meshes are subuniform in size, and 17–18 of them border the girdle posteriorly on each valve. The pores are few and scattered. A few small, round phaeosomes were found in the girdle of the type specimen.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 17.2 μ. Greatest depth of body, 17.8 μ. Total length, 29 μ.

Comparisons: — The description given above is based on the type specimen.

Histioneis inclinata appears to be a representative of an evolutionary branch which split off at a fairly early stage in the phylogenetic differentiation of this genus and in which either the increase in size of the posterior portion of the left sulcal list was inhibited or in which this portion became subject to reduction. The small size, the subrotund shape of the body, the shape of the anterior cingular list, and the shape and structure of the posterior cingular list place it among the most primitive species of this genus. The straight, subhorizontal fission rib of the left sulcal list is also a primitive feature. The structure of the anterior cingular list is simple, but exhibits characteristics that recall *H. costata* and *H. carinata*. The small size, rounded shape, and peculiar structure of the portion of the left sulcal list which is behind the fission rib are unique features by which *H. inclinata* can readily be distinguished from the remaining species of this genus. Its closest relative is probably *H. inornata* (see this species, the section on comparisons).

Occurrence: — *Histioneis inclinata* is recorded at two of the 127 stations. These two stations (4720, 4728) are located on the fifth line of the Expedition and in the South Equatorial Drift. Only two specimens were found, both occurring in Salpa taken in surface waters. The surface temperatures of these two stations were 76° and 77°, respectively.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4720 of the Expedition, which thus is the type locality. The restriction of the record stations to the South Equatorial Drift is noteworthy.

Histioneis inornata Kofoid and Michener

Figure 85: 2; 95: 10

Histioneis inornata Kofoid & Michener, 1911, p. 297.

Diagnosis: — Body subrotund in lateral outline, truncate anteriorly; length: depth, 0.83: 1. Dorsally the transverse furrow is 0.53 the depth of body, three times wider than ventrally, inclined dorsoposteriorly at 8°, and gently concave. Distance from apex to posterior cingular list 0.11–0.12 the base of this list. Anterior cingular list with long stalk, flaring dorsally in its distal 0.16; its height 1.03 the depth of body. Dorsal height of posterior cingular list 0.76 the depth of body. Left sulcal list short, ending about midway between R_2 and antapex, rounded and recurved posteriorly; R_2 straight, inclined anteriorly at 10°, 0.30 the depth of

body; R_3 marginal, short, 0.22 the depth of body, strikingly concave dorsally, directed posteriorly. Theca with pores only. Total length, 34 μ.

Eastern tropical Pacific.

Description: — This species is very small, its body subrotund in lateral outline, truncate anteriorly, and deepest near the girdle. The ratio between the length and the depth of the body is about 0.83: 1. The longitudinal axis is deflected posterodorsally at about 7°.

The epitheca is about 0.10 as deep as the hypotheca, flat, and subhorizontal. Dorsally the transverse furrow is about 0.53 the greatest depth of the body, about three times wider than ventrally, inclined dorsoposteriorly at about 8° to the horizontal plane, and gently concave. The distance from the apex to the posterior cingular list is only about 0.11–0.12 the base of this list. The hypotheca is subsymmetrical; the anterior margin is subhorizontal and but slightly concave; the ventral, posterior, and dorsal margins are well convex and confluent; the ventral margin is somewhat more rounded than the dorsal. In dorsoventral view the hypotheca is about as wide as long, ellipsoidal, with evenly convex side contours, and well rounded posteriorly.

The anterior cingular list has a long, slender stalk and is about 5.6 times wider distally than basally; its height is about 1.03 the greatest depth of the body, and its right side is but slightly lower than its left; in the type specimen it appeared to lack structural differentiation. Its stalk flares a trifle, enlarging abruptly in its distal 0.16 in an asymmetrical funnel, with a mainly dorsal flare. The posterior cingular list is closed and lacks structural differentiation except the dorsal and ventral ribs and the cross-rib; its dorsal height is about 0.76, its ventral height about 0.71 the greatest depth of the body; its frill is narrow, about 0.10 the dorsal rib; and it is moderately bulging. The left sulcal list is simple in shape and short, ending about midway between the fission rib and the antapex; its ventral margin is gently sigmoid, concave anteriorly, convex posteriorly; its posterior portion is well rounded, and recurved dorsally, and it has no structural differentiation except the fission rib and the posterior rib. The fission rib is straight, inclined anteriorly at about 10°, and about 0.30 the greatest depth of the body. The posterior rib is marginal, rather weak, short, about 0.22 the depth of the body, strikingly concave dorsally, and directed posteriorly; at its tip the margin of the list is subrectangular.

The thecal wall is smooth. Along the anterior margin of the hypotheca there is a series of about ten pores. Phaeosomes were not seen.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 14.3 μ. Greatest depth of body, 17.3 μ. Total length, 34 μ.

Comparisons: — The description given above is based on the type specimen.

Histioneis inornata is in several respects very primitive and occupies a somewhat isolated position near the base of the evolutionary scale of Histioneis. It is structurally more closely related to *H. inclinata* than to any of the other species of this genus. The fact that the differences between these species are more marked than the similarities, indicates, however, that we are concerned with representatives of two different evolutionary lines. The most important distinguishing characteristics are to be found in the shape of the anterior cingular list and in the shape, structure, and relative size of the posterior portion of the left sulcal list. The size, shape, and structure of the left sulcal list of *H. inornata* distinguish this species from all the other known members of this genus. Note, for instance, the curved marginal and exceptionally short posterior main rib of this list.

Occurrence: — *Histioneis inornata* is recorded at only one of the 127 stations, 4720, on the fifth line of the Expedition in the South Equatorial Drift, in a Salpa taken in surface waters, at a surface temperature of 76°.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4720 of the Expedition, which thus is the type locality.

Histioneis reginella Kofoid and Michener

Plate 20, fig. 9, 11. Figure 95: 2

Histioneis reginella Kofoid & Michener, 1911, p. 296, 299, 300.

Diagnosis: — Body subrotund in lateral outline, truncate anteriorly; length: depth, 0.96: 1. Dorsally the transverse furrow is 0.46 the depth of body, three times wider than ventrally, subhorizontal, and gently concave. Distance from apex to posterior cingular list 0.20 the base of this list. Anterior cingular list with stalk of moderate length, flaring in the distal 0.5 in a wide, ventrally notched funnel; its height 1.20 the depth of body. Posterior cingular list forms big, rather narrowly rounded lateral pouches, which have irregular reticulation distally; its dorsal height 0.81 the depth of body; cross-rib with some short alternating branches. Left sulcal list extends somewhat beyond a point midway between flagellar pore and antapex, then turns anteriorly, and ends near posterior end of longitudinal furrow; of moderate width; ventral portion strikingly curled to the right; posterior portion slightly bilobed, extending but little behind antapex;

with irregular, moderately developed reticulation. Theca with pores only. Total length, 55 μ.

Eastern tropical Pacific.

Description: — This species is fairly small, subrotund in lateral outline, truncate anteriorly, and deepest near the middle. The ratio between the length and the depth of the body is about 0.96: 1. The longitudinal axis is deflected posterodorsally at about 10°.

The epitheca is about 0.17 as deep as the hypotheca, flat, and subhorizontal. Dorsally the transverse furrow is about 0.46 the greatest depth of the body, about three times wider than ventrally, subhorizontal, and gently concave. The distance from the apex to the posterior cingular list is about 0.20 the base of this list. The hypotheca is subsymmetrical; the anterior margin is inclined dorsoanteriorly at 10°–15° to the horizontal plane and moderately concave; the ventral, posterior, and dorsal margins are well convex and confluent, but the convexity is somewhat more pronounced posteroventrally than posterodorsally. In dorsoventral view the body has about the same shape as in lateral view, but it is distinctly narrower.

The anterior cingular list has a stalk of moderate length and is about six times wider distally than basally; it flares in its distal 0.5 in a very wide subsymmetrical funnel (seen obliquely in Figure 95: 2) with an acute ventral notch; its height is about 1.20 the greatest depth of the body, and its right side is but slightly lower than its left; along its entire distal edge this list has a submarginal rib with a moderate number of short branches on both sides; and just behind this rib it has dorsally an irregular and fairly coarse reticulum. The posterior cingular list is closed and forms on both sides a big, rather narrowly rounded pouch; when seen in dorsoventral view, each pouch is somewhat narrower than the body; the dorsal height is about 0.81, the ventral height about 0.93 the greatest depth of the body; the frill is of moderate height, about 0.27 the dorsal rib; the cross-rib has a moderate number of short, alternating branches; and each pouch has distally an irregular reticulum, from which a simple rib runs on the posterior side to the base of the list. The left sulcal list extends somewhat beyond a point midway between the flagellar pore and the antapex, then turns anteriorly on the right side of the body, and ends near the posterior end of the longitudinal furrow. It is of moderate width; its ventral portion is strikingly curled to the right; and its posterior portion is subtruncate, slightly bilobed, and extends but little behind the antapex. The anterior main rib has two branches near the middle. The anterior fission rib is recurved anteriorly and has a few short distal branches. The posterior fission rib is simple, subhorizontal, and about 0.62 the greatest depth of the body.

Posteriorly this list has two ribs; one of these is simple, rather short, about 0.34 the greatest depth of the body, deflected posteroventrally at about 20°, and ends between the two posterior lobes of this list; the other is located just in front of the first and has two branches, one fairly short posterior, and one long anterior, which distally branches into a coarse, irregular reticulum.

The thecal wall is smooth. The hypotheca has a close-set row of pores along the girdle and a moderate number of scattered pores. In the transverse furrow there are two dense rows of pores, one along the posterior cingular list and one along the sagittal suture. Numerous fairly small, ovoidal phaeosomes were found in the girdle of the type specimen.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 23.3 μ. Greatest depth of body, 24.3 μ. Total length, 55 μ.

Comparisons: — The description given above is based on the type specimen.

Histioneis reginella occupies a rather isolated position. It is especially characterized by the subrotund body, the relatively wide anterior opening of the anterior cingular list, the narrowness of the frill, the large lateral pouches of the posterior cingular list, and by the relatively short, strikingly curled left sulcal list, the posterior end of which turns anteriorly on the right side of the body and the posterior fission rib of which is subhorizontal. In the large lateral pouches of the posterior cingular list it resembles *H. panaria*, but it differs strikingly from this species in the shape of the body and in the shape and structure of the left sulcal list. In the shape of the body and of the anterior cingular list and to some extent also in the structure of the left sulcal list it recalls *H. gubernans;* but again, a close relationship to this species is brought in doubt by the large lateral pouches of the posterior cingular list and by the curved and curled shape of the left sulcal list.

Occurrence: — *Histioneis reginella* is recorded at only one of the 127 stations, 4681, on the third line of the Expedition and in the South Equatorial Drift, in a haul from 300–0 fathoms, at a surface temperature of 68°. The frequency is less than 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4681 of the Expedition, which thus is the type locality.

Histioneis panaria, sp. nov.

Figure 85: 8, 9; 95: 6

Diagnosis: — Body sausage-shaped; dorsal and ventral heights subequal; length: depth, 0.49: 1. Dorsally the transverse furrow is 0.59 the depth of body, eight times wider than ventrally, inclined dorsoanteriorly at 25°–30°, and strongly concave. Distance from apex to posterior cingular list 0.09 the base of this list. Anterior cingular list with stalk of moderate length, flaring gradually from very near its base with an increase in its distal 0.5 so that a slight concavity results, with broad ventral notch, deflected dextrally nearly 90°, and a dextroventral inclination of 45°; its height subequal to depth of body. Posterior cingular list forms big, broadly rounded lateral pouches; its dorsal height 0.51 the depth of body; frill broad, 0.56 the dorsal rib, with about ten simple, longitudinal ribs on each valve. Left sulcal list: R_2 almost straight, inclined posteriorly at 70°, and 0.35 the depth of body; R_3 marginal, weak, simple, gently concave dorsally, 0.68 the depth of body, located midway between midline and antapex, inclined posteroventrally at 20°–25°; ventral margin gently sigmoid, convex posteriorly; posterior end narrowly rounded. Total length, 62 μ.

Eastern tropical Pacific.

Description: — This species has a rather small body, sausage-shaped in lateral outline, and its dorsal and ventral heights are subequal. The ratio between the length and the depth of the body is about 0.49: 1. The longitudinal axis is deflected posterodorsally at about 30°–35°.

The epitheca is about 0.10 as deep as the hypotheca, gently convex, highest in the center, and subhorizontal. Dorsally the transverse furrow is about 0.59 the greatest depth of the body, about eight times wider than ventrally, inclined dorsoanteriorly at 25°–30° to the horizontal plane, and strongly concave. The distance from the apex to the posterior cingular list is only about 0.09 the base of this list. The anterior margin of the hypotheca is inclined dorsoanteriorly at about 25°, and well concave, subsemicircular; the dorsal, posterior, and ventral margins are confluent and well convex, subsemicircular. In dorsoventral view the body is ovate, about 1.4 times longer than wide, and wider near the middle.

The anterior cingular list has a stalk of moderate length and is about seven times wider distally than proximally; its height is subequal to the greatest depth of the body. It flares through nearly its whole length but more in the distal 0.5 with resulting concavity more accentuated near its middle. It exhibits a maximum amount of dextral torsion with the wide ventral notch nearly 90° from the

midventral plane of the body and a dextroventral inclination of the subsymmetrical top of about 45°. There is much less torsion in the postcingular list. On the left valve it has distally about ten simple, equidistant ribs, the bases of which are connected by a transverse rib; on the right valve it has a somewhat smaller number of distal ribs, the middle portions of which are connected by a transverse rib. The posterior cingular list is closed and forms on both sides a broadly rounded lateral pouch; when seen in dorsoventral view, each pouch is slightly wider than the body; the dorsal and ventral heights are subequal and about 0.51 the greatest depth of the body; the frill is broad, about 0.56 the dorsal rib; the list lacks structural differentiation except the dorsal and ventral ribs, the cross-rib, and, on each valve, about ten simple, subequidistant, longitudinal ribs in the frill. The left sulcal list is of moderate size, simple in shape and structure, and has only two ribs, the fission rib and the posterior main rib. The fission rib is almost straight, inclined posteriorly at about 70°, and about 0.35 the greatest depth of the body. The posterior main rib is marginal, weak, simple, gently concave dorsally, about 0.68 the greatest depth of the body, located about midway between the midline and the antapex, and inclined posteroventrally at 20°–25°. The ventral margin of this list is gently sigmoid, concave anteriorly, convex posteriorly; and the posterior end of the list is narrowly rounded.

The structure of the theca was not recorded. Phaeosomes were not observed.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 14.3 μ. Greatest depth of body, 29.3 μ. Total length, 62 μ.

Comparisons: — This species is established on two outline drawings of a single specimen found in the material of the Expedition. Although our description is incomplete and perhaps somewhat uncertain in a few details on account of the fact that the type specimen was lost before the drawings were completed, it probably is sufficient for full certainty of specific identification.

Histioneis panaria is very aberrant and occupies an isolated and uncertain position in the natural system of its genus. The shape of its body and the shape and structure of its posterior cingular list are very advanced. Its left sulcal list, on the other hand, has remained relatively simple in size, shape, and structure. An especially important feature is that the posterior fission rib of the left sulcal list is nearly straight. The species shows marked similarities to *H. panda,* but these cannot be considered as indicative of a close relationship, since *H. panda* is a very highly specialized representative of the PULCHRA group, in which even the most primitive members have the posterior fission rib of the left sulcal list

recurved dorsally. *H. panaria* is easily recognized from all the other species of this genus by having at the same time the left sulcal list simple in structure and the posterior cingular list furnished with large lateral pouches.

Occurrence: — *Histioneis panaria* is recorded at only one (4724) of the 127 stations, on the fifth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, at a surface temperature of 79°. The frequency is less than 1%.

2. Remora Group. Of the four species of this group only *Histioneis remora* was not found in the material of the Expedition. The others have been treated in the following order: — *H. elongata*, *H. carinata*, and *H. navicula*, suggestive of relationships.

Histioneis elongata Kofoid and Michener

Plate 20, fig. 7; Plate 22, fig. 4, 6, 7. Figure 96:3

Histioneis elongata Kofoid & Michener, 1911, p. 295. Jörgensen, 1923, p. 39.

Diagnosis: — Body obliquely subrotund in lateral outline; length: depth, 1.13:1. Dorsally the transverse furrow is 0.47 the depth of body, inclined dorsoposteriorly at 30°–35°, 3.4 times wider than ventrally, and gently concave. Distance from apex to posterior cingular list 0.26 the base of this list. Anterior cingular list with short stalk, gradually flaring distally; its height 1.07 the depth of body. Posterior cingular list with a few ribs in frill; its dorsal height 0.95 the depth of body. Left sulcal list long and narrow, with submarginal rib between main ribs and posterior reticulation; R_2 straight, 0.57 the depth of body, inclined posteriorly at 30°; R_3 of moderate strength, submarginal, 2.14 the depth of body, located on midline, directed posteriorly; ventral margin sigmoid, rather strongly convex in the middle; posterior angle, 20°–30°. Theca reticulate. Total length, 116 μ.

Eastern tropical Pacific.

Description: — This is a medium-sized, obliquely subrotund species. The ratio between the length and the depth of the body is about 1.13:1. The longitudinal axis is deflected posterodorsally at 15°–20°.

The epitheca is about 0.23 as deep as the hypotheca, slightly convex, highest in or near the center, and tilted dorsoposteriorly at 5°–10°. Dorsally the transverse furrow is about 0.47 the greatest depth of the body, about 3.4 times wider than ventrally, inclined dorsoposteriorly at 30°–35° to the horizontal plane, and gently concave. The distance from the apex to the posterior cingular list is about 0.26 the base of this list. The anterior margin of the hypotheca is gently concave and inclined dorsoposteriorly at 15°–20° to the horizontal plane; the ventral,

posterior, and dorsal margins are confluent; the dorsal margin is somewhat more rounded than the posterior and ventral margins, and the postmargin is subparallel to the anterior margin. In dorsoventral view the body is about 1.6 times longer than wide and widest in the middle; the outline of the hypotheca is ellipsoidal; the anterior portion of the body is rounded conical, with gently concave sides.

The anterior cingular list has a fairly short but distinct stalk and is about 4.3 times wider distally than basally, flaring in the distal 0.5 in a concave cone of approximately 60°; its height is about 1.07 the greatest depth of the body, and its right side is strikingly lower than its left; it has on both valves several ribs, the proximal ends of which are poorly or not at all developed; the number of ribs on the right valve is smaller than on the left; the dorsal rib on each valve is branched (Plate 22, fig. 4); the ends of the ribs project slightly beyond the edge of the list. The posterior cingular list is closed and lacks structural differentiation except the dorsal and ventral ribs, the cross-rib, and a few (two in the type specimen) ribs in the frill; its dorsal height is about 0.95, its ventral height about 0.72 the greatest depth of the body; it bulges but slightly or not at all, and its frill is narrow, about 0.14 the dorsal rib. The left sulcal list is simple in shape and has two main ribs, between which there is a submarginal rib, and heavy reticulation posteriorly. The fission rib is straight, about 0.57 the greatest depth of the body, and inclined posteriorly at about 30°. The posterior rib is of moderate strength, submarginal proximally and marginal distally, with a few short and weak secondary ribs, about 2.14 the greatest depth of the body, gently concave dorsally, located on or near the midline, and directed posteriorly. The ventral margin of this list is sigmoid, rather strongly convex in the middle; the dorsal margin is moderately concave. The ventral and dorsal margins form a posterior angle of about 20°–30°. Except for the ribs and reticulation mentioned above and a couple of very short ribs dorsally to the posterior rib, this list lacked structural differentiation in the type specimen.

The thecal wall is reticulated. The meshes are of subuniform size and closely set. On each valve about 13–14 meshes border the girdle posteriorly. The pores are scattered and much fewer than the meshes. A few small, ovoidal phaeosomes were found in the girdle of the type specimen.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 31.4 μ. Greatest depth of body, 27.9 μ. Total length, 116 μ.

Comparisons: — Our description and figures are based on the type specimen.

Histioneis elongata undoubtedly is most closely related to *H. remora*. These species differ in the shape of the anterior cingular list and, especially, in the shape

of the hypotheca, which is symmetrical in *H. remora* and strikingly asymmetrical in *H. elongata*. The ventral split in the anterior cingular list, as well as the dorsal split and the absence of a frill in the posterior cingular list in Stein's (1883, pl. 22, fig. 11) figure of *H. remora* evidently are due to Stein's overlooking parts of these delicate membranes. The marked lack of asymmetry in Stein's *H. remora* as compared with *H. elongata* may be due in part at least to the general tendency in Stein's delineations of this genus to accentuate all the symmetrical features. Our own observations as shown in our attempts at an accurate delineation of these most elaborate organisms do not confirm this trend so strikingly shown in Stein's figures. This is an exception to the general evaluation of the work of this indefatigable pioneer in protozoölogy, for as a general rule his figures are exceptional in the accuracy of detail with which he portrayed the Protozoa. His sense of symmetry and proportion was evidently too strong when he drew Histioneis. The highly developed structure of the left sulcal list of the type specimen of *H. remora* indicates that this specimen was further advanced ontogenetically than the specimen of *H. elongata* represented by our Plate 22, figure 7. The question of the specific separation of these two forms cannot be regarded as settled but should be reconsidered. For further discussion about the relationships of these species, see *H. carinata* and *H. navicula*, the sections on comparisons.

Synonymy: — This species was established by Kofoid and Michener (1911) under the name of *Histioneis elongata*. This name was considered by Jörgensen (1923, p. 39) as a possible synonym of *H. remora* Stein. With regard to *H. remora* Jörgensen (1923), see *H. carinata*, the section on synonymy.

Occurrence: — *Histioneis elongata* is recorded at three of the 127 stations. All of these three stations (4722, 4730, 4734) are located on the fifth line of the Expedition and in the South Equatorial Drift. The depth is 300–0 fathoms, the surface temperature 78.3° (75°–81°), and the frequency in each case less than 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4722 of the Expedition, which thus is the type locality. The restriction of the three record stations to the South Equatorial Drift is noteworthy.

Histioneis carinata Kofoid

Plate 21, fig. 1, 8. Figure 95: 1

Histioneis carinata Kofoid, 1907a, p. 203, pl. 16, fig. 98.
? *Histioneis paulseni* Okamura, 1912, p. 21, pl. 3, fig. 53, 54.
? *Histioneis remora* Jörgensen, 1923, p. 39, fig. 55.

Diagnosis: — Body of short canoe-shape, distinctly higher ventrally than dorsally; length: depth, 0.63: 1. Dorsally the transverse furrow is 0.54 the depth

of body, 5 times wider than ventrally, inclined dorsoposteriorly at 15°–20°, and gently concave. Distance from apex to posterior cingular list 0.11 the base of this list. Anterior cingular list with stalk about 0.4 its total height and including an angle of 70°; its height 0.60 the depth of body. Posterior cingular list with slight ventral reticulation; its dorsal height 0.59 the depth of body. Left sulcal list with well-developed reticulation; R_2 straight, 0.18 the depth of body, inclined posteriorly at 25°–30°; R_3 marginal, strong, reticulated posteriorly, 0.63 the depth of body, located on midline, directed posteriorly; ventral margin sigmoid, well convex posteriorly; narrowly rounded or subangular posteriorly. Theca reticulate. Total length, 88 μ.

Eastern tropical Pacific.

Description: — This is a medium-sized species of short canoe-shape, distinctly higher ventrally than dorsally. The ratio between the length and the depth of the body is about 0.63: 1. The longitudinal axis is deflected posterodorsally at about 15°–20°.

The epitheca is about 0.19 as deep as the hypotheca, slightly convex, highest in or near the center, and tilted ventroposteriorly at about 10°. Dorsally the transverse furrow is about 0.54 the greatest depth of the body, about five times wider than ventrally, inclined dorsoposteriorly at 15°–20° to the horizontal plane, and gently concave. The distance from the apex to the posterior cingular list is only about 0.11 the base of this list. The anterior margin of the hypotheca is inclined dorsoposteriorly at about 10° to the horizontal plane and moderately sigmoid, convex ventrally, and concave dorsally; the ventral, posterior, and dorsal margins are confluent; the ventral and dorsal margins are well rounded, the posterior margin is gently rounded. In dorsoventral view the body is about 1.2 times longer than wide, widest in the middle; the outline of the hypotheca is subcircular; the anterior portion of the body is rounded conical, with gently concave sides.

The anterior cingular list has a short but distinct stalk and is about three times wider distally than basally; its height is about 0.60 the greatest depth of the body, and its right side is strikingly lower than its left. The short stalk is about 0.4 the total height. The flaring funnel has straight sides, the ventral much steeper than the dorsal, and the angle included between the two is about 70°. On the right valve it has only three ribs, the ventral one of which is simple, the dorsal furnished with one short distal branch, and the middle with three branches; on the left valve it has about 14–15 ribs, the proximal parts of which form a reticulum; the ends of the ribs project slightly beyond the edge of the list. The posterior cingular list was open ventrally in the type specimen but is probably closed

when fully developed just as in *Histioneis navicula;* or the delicate membrane may have been overlooked; it lacks structural differentiation except the dorsal and ventral ribs, the cross-rib, and a slight reticulation between the bases of the ventral ribs; its dorsal height is 0.59, its ventral height 0.34 the greatest depth of the body; it bulges but slightly; its frill is narrow, 0.14 the dorsal rib. The left sulcal list is simple in shape, and has two main ribs and well-developed reticulation. The fission rib is straight, about 0.18 the greatest depth of the body, and inclined posteriorly at about 15°. The posterior rib is marginal, strong, reticulated distally, sometimes with a few short and weak secondary ribs, about 0.63 the greatest depth of the body, sigmoid, concave anteriorly, convex posteriorly, located on or near the midline, and directed posteriorly. The ventral margin of this list is sigmoid, moderately concave anteriorly, and well convex posteriorly. Its posterior end is narrowly rounded or subangular. Basally between the fission rib and the posterior rib as well as posteriorly, this list is heavily reticulated with subhorizontally elongated reticulation; and in front of the fission rib it has fine reticulations of the subcircular type.

The thecal wall is reticulated. The meshes are fairly closely set and of subuniform size. On each valve about 21 meshes border the girdle posteriorly. In most of the meshes a central pore is to be found. A few small, ovoidal phaeosomes were found in the girdle of the type specimen.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 31.4 μ. Greatest depth of body, 50.0 μ. Total length, 88 μ.

Comparisons: — The description given above is based on the type specimen.

Histioneis carinata appears to be most closely related to *H. elongata* and *H. navicula,* and in several respects occupies structurally an intermediate position between these two species. From *H. elongata* it is easily recognized by its relatively deeper body and narrower left sulcal list. It differs from *H. navicula* in its less depressed body, in its relatively narrower transverse furrow and smaller posterior cingular list, and in the longer and stronger posterior main rib of the left sulcal list. Another close relative is *H. remora,* a species very nearly related to and possibly somewhat more primitive than *H. elongata.* It should also be mentioned that *H. biremis* and *H. highleyi* probably originated from an ancestral form fairly closely resembling *H. carinata.* These two species are readily recognized from *H. carinata,* as well as from all the other species of this genus, by the posterior spur-like projection of the body. *Parahistioneis paraformis* (Plate 19, fig. 3), which has the posterior rib of the left sulcal list of about the same size,

structure, and position as in the present species, probably is structurally fairly close to the ancestral form from which originated the group of species mentioned in this section (see also *Histioneis navicula*, the section on comparisons).

The specimen represented by Figure 85: 4 has been referred to *Histioneis carinata*, but it is of a somewhat uncertain specific allocation. In several respects it is intermediate between this species and *H. navicula;* for instance, in the shape and structure of the left sulcal list it approaches *H. carinata*. This specimen is not considered in our description of *H. carinata*, and its locality is not included in the distributional data.

Synonymy: — This species was established by Kofoid (1907a) under the name of *Histioneis carinata*. The specimens from Japanese waters recorded by Okamura (1912, p. 21, pl. 3, fig. 53, 54) as *H. paulseni* are too inadequately figured for certainty of specific assignment. At least one of them (fig. 53a), however, appears to belong to *H. carinata*. The relatively short dorsoventral diameter and the greater dorsal height of the body in this specimen as drawn by Okamura probably are only apparent and due to foreshortening. The specimen represented by Okamura's (1912) figure 54a may also belong to this species, but the structure of its left sulcal list makes this assignment quite uncertain. The shortness of the dorsoventral diameter of the body is probably at least to some extent due to foreshortening. The specimen from the Mediterranean figured by Jörgensen (1923, fig. 55) as *H. remora* resembles *H. carinata* rather closely, except in the greater posterior width and the weaker posterior main rib of the left sulcal list, in which respects it is intermediate between *H. carinata* and *H. remora*. This specimen can hardly be referred to *H. remora*, but its assignment to *H. carinata* is also questionable. We have not included these specimens of Okamura (1912) and Jörgensen (1923) in our description or in our account of the distribution of *H. carinata*, but they have tentatively been assigned to this species.

Occurrence: — *Histioneis carinata* is recorded at only one (4724) of the 127 stations, on the fifth line of the Expedition and in the South Equatorial Drift, from 300–0 fathoms, at a surface temperature of 79°. The frequency is less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4724 (not 4734 as stated originally) of the Expedition, which thus is the type locality (see also the section on synonymy).

Histioneis navicula Kofoid

Plate **21**, fig. 3, 6. Figure 95: 3

Histioneis navicula Kofoid, 1907a, p. 204, pl. 16, fig. 96. Kofoid & Michener, 1911, p. 298.

Diagnosis: — Body canoe-shaped, somewhat higher ventrally than dorsally; length: depth, 0.52: 1. Dorsally the transverse furrow is 0.77 the depth of body, 11 times wider than ventrally, inclined dorsoposteriorly at 10°–15°, and well concave. Distance from apex to posterior cingular list 0.10 the base of this list. Anterior cingular list with short stalk, flaring asymmetrically dorsosinistrally; its height 0.75 the depth of body. Posterior cingular list large; its dorsal height 0.75 the depth of body; frill with slight reticulation dorsally and ventrally and with a few ribs. Left sulcal list: R_2 straight, 0.12 the depth of body, inclined posteriorly at 40°–50°; R_3 weak, submarginal, with short distal branches, 0.36 the depth of body, located somewhat dorsally to midline, inclined posteroventrally at 10°–15°; ventral margin sigmoid, convex posteriorly, partly curled to the right; posterior angle, 60°–70°. Theca reticulate. Total length, 87 μ.

Eastern tropical Pacific.

Description: — This is a fairly large species, with canoe-shaped body, distinctly higher ventrally than dorsally. The ratio between the length and the depth of the body is about 0.52: 1. The longitudinal axis is deflected posterodorsally at about 30°–35°.

The epitheca is about 0.12 as deep as the hypotheca, slightly convex, highest somewhat dorsally to the center, and tilted ventroposteriorly at about 10°. Dorsally the transverse furrow is about 0.77 the greatest depth of the body, about eleven times wider than ventrally, inclined dorsoposteriorly at 10°–15° to the horizontal plane, and well concave. The distance from the apex to the posterior cingular list is only about 0.10 the base of this list. The shape of the hypotheca determines the shape of the body as a whole, since the anterior margin extends almost as far anteriorly as that of the transverse furrow. The anterior margin of the hypotheca is inclined dorsoposteriorly at about 5°–10° to the horizontal plane and is somewhat less concave than the transverse furrow; the ventral margin is well and broadly rounded; the posterior margin is flat and confluent with the ventral margin; the short dorsal margin forms a broadly rounded corner with the posterior margin. In dorsoventral view the body is about 1.6 times longer than wide and widest in the middle; the outline of the hypotheca is ellipsoidal; the anterior portion of the body is rounded conical, with gently concave sides.

The anterior cingular list has a short but distinct stalk and is about 5.7 times

wider distally than basally; its height is about 0.75 the greatest depth of the body, and its right side is strikingly lower than its left. It flares distally, beginning very near the base, and increases at an accelerated rate dorsosinistrally to a distal angle of 80°. On the right valve it has only two ribs, the ventral one of which is simple, the dorsal furnished with five to six branches; on the left valve it has 10–15 irregular ribs, the proximal ends of which form a reticulum; the tips of the ribs project slightly beyond the edge of the list. The posterior cingular list is closed and lacks structural differentiation except the dorsal and ventral ribs, the cross-rib, and a slight reticulation dorsally and ventrally and a few ribs on the frill; its dorsal height is 0.75, its ventral height 0.39 the greatest depth of the body; it bulges moderately dorsally and but slightly laterally; and its frill is narrow, 0.16 the dorsal rib. The left sulcal list is simple, with the posterior half of the ventral margin recurved to the right, and with only two ribs. The fission rib is straight, very weak, about 0.12 the greatest depth of the body, and inclined posteriorly at 40°–50°. The posterior rib is stronger, submarginal proximally, marginal distally, with short distal branches both horizontal and vertical in direction, almost straight, about 0.36 the greatest depth of the body, located somewhat dorsally to the midline, and inclined posteroventrally at 10°–15°. The ventral margin of this list is sigmoid, moderately concave anteriorly, and convex posteriorly. The ventral and dorsal margins of this list form a posterior angle of 60°–70°. The dorsal margin is gently concave. Except for the ribs mentioned above, this list appears to lack structural differentiation.

The thecal wall is reticulated. The meshes are closely set and of subuniform size. On each valve about 33 meshes border the girdle posteriorly. Pores were not observed. A few small ovoidal phaeosomes were found in the girdle of the type specimen.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 31.2 μ. Greatest depth of body, 59.6 μ. Total length, 87 μ.

Comparisons: — The description given above is based on the type specimen.

Histioneis navicula probably is most closely related to *H. carinata.* This relationship is suggested by the depressed shape of the body, by the similarities in the shape and structure of the anterior cingular list, and by the simple and almost similar structure of the posterior cingular list. The first species is readily distinguished from the last by its more depressed body, by its relatively wider transverse furrow and larger posterior cingular list, and by the shorter and weaker posterior rib in its left sulcal list. In the degree of depression of the body, in the

relative width of the transverse furrow, and in the relative size of the posterior cingular list, *H. navicula* represents the end link in the orthogenetic series: *H. remora* — *H. carinata* — *H. navicula*. In the shape and structure of the anterior cingular list the two last species have reached almost the same evolutionary stage. In the relative width and in the structure of the left sulcal list *H. navicula* is the most primitive.

Occurrence: — *Histioneis navicula* is recorded at three of the 127 stations. All of these three stations are in the South Equatorial Drift, and one of them (4701) is on the fourth and two (4733, 4734) are on the fifth line of the Expedition. At one station (4733) the species was found in surface waters (in Salpa); the two remaining records refer to hauls from 300–0 fathoms.

The temperature range of these three stations at the surface was 72°–81°; the average was 77.7°. The frequency is in all cases less than 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4734 of the Expedition which thus is the type locality. The restriction of the three record stations to the South Equatorial Drift is noteworthy.

3. Biremis Group. Both the species belonging to this group, viz., *Histioneis biremis* and *H. highleyi*, were recorded from the material of the Expedition.

Histioneis biremis Stein

Figure 97; 95: 11

Histioneis biremis Stein, 1883, pl. 22, fig. 13. Bütschli, 1885, p. 943. Murray & Whitting, 1899, p. 332, pl. 32, fig. 6, tab. 3, 6, 8, 9. Lemmermann, 1899, p. 374. Kofoid, 1907a, p. 204.

Diagnosis: — Body obliquely depressed; with posterodorsal protuberance 1.3–2.3 times longer than deep; length : depth, 0.99–1.08 : 1. Dorsally the transverse furrow is 0.55–0.65 the depth of body, three to six times wider than ventrally, inclined dorsoposteriorly at 25°–30°, and gently or moderately concave. Distance from apex to posterior cingular list 0.08–0.23 the base of this list. Anterior cingular list with short stalk flaring widely distally; its height 0.59–0.81 the depth of body. Dorsal height of posterior cingular list 0.64–0.85 the depth of body. Left sulcal list with two main ribs, between which may be some short ribs, reticulation, or a submarginal rib; R_2 almost straight, inclined posteriorly at 5°–30°, and 0.22–0.33 the depth of body; R_3 usually marginal, strong, reticulated distally, 0.85–1.20 the depth of body, located on midline, and inclined posteroventrally at 1°–15°; margin between R_2 and R_3 gently sigmoid or convex; angular at 10°–30° or

narrowly rounded posteriorly. Theca areolate and porulate. Total length, 101–193 μ.

Widely distributed in warm seas.

Description: — This is a large, strikingly asymmetrical species, in which the body is postero-obliquely depressed and furnished with a spur-like posterodorsal protuberance. The ratio between the length and the depth of the body is 1.03 (0.99–1.08) : 1. The longitudinal axis (drawn through the apex and the posterior end of the posterior process) is inclined posterodorsally at 40° (35°–45°).

The epitheca is 0.21 (0.19–0.22) as deep as the hypotheca, slightly convex, highest in or near the center, and subhorizontal or tilted dorsoposteriorly at 1°–10°. Dorsally the transverse furrow is 0.60 (0.55–0.65) the greatest depth of the body, three to six times wider than ventrally, inclined dorsoposteriorly at 25°–30° to the horizontal plane, and gently or moderately concave. The distance from the apex to the posterior cingular list is 0.17 (0.08–0.23) the base of this list. The hypotheca is strikingly asymmetrical and has a spur-like posterodorsal protuberance, which is about 1.3–2.3 times longer than deep and well rounded distally. The anterior margin of the hypotheca is inclined dorsoposteriorly at 13° (8°–15°) to the horizontal plane, gently sigmoid, convex ventrally and concave dorsally (Murray and Whitting, 1899, pl. 32, fig. 6), gently concave (Stein, 1883, pl. 22, fig. 13), or almost straight (Figure 97: 3); the ventroposterior margin is strongly sigmoid, convex ventrally, and concave posterodorsally; the dorsal margin is almost straight (Murray and Whitting, 1899, pl. 32, fig. 6), gently concave (Figure 97: 1, 3), or gently sigmoid, convex anteriorly and concave posteriorly (Stein, 1883, pl. 22, fig. 13).

The anterior cingular list has a short but distinct stalk and is about three to five times wider distally than basally; its height is 0.72 (0.59–0.81) the greatest depth of the body, and its right side is strikingly lower than its left; the sides of the flaring funnel are straight but longer dorsally; its structure appears always to be about the same as in *Histioneis carinata*. The posterior cingular list, when fully developed, appears to be closed; it lacks structural differentiation except the dorsal and ventral ribs, and the cross-rib; its dorsal height is 0.74 (0.64–0.85), its ventral height 0.48 (0.39–0.59) the greatest depth of the body; its frill is rather narrow, 0.19 (0.17–0.21) the dorsal rib; and usually it is but slightly if at all bulging (for exception, see Figure 97: 2). The left sulcal list is simple in shape and has two main ribs and between these, in older specimens, a few short ribs, reticulation, and a more or less developed submarginal rib. The fission rib is straight or gently sigmoid, 0.27 (0.22–0.33) the greatest depth of the body, and inclined

posteriorly at 15° (5°–30°). The posterior rib is strong, reticulated distally, sometimes with a few short and weak secondary ribs (Murray and Whitting, 1899, pl. 32, fig. 6), 1.01 (0.85–1.20) the greatest depth of the body, somewhat concave dorsally, located about midway between the transverse furrow and the posterodorsal spur-like protuberance of the body, inclined posteroventrally at 1°–15°, and either marginal throughout, or its proximal half is submarginal (Figure 97: 1, 2), or the list extends to the base of the posteroventral protuberance, in which case the portion of the list dorsal to this rib is very low (Murray and Whitting, 1899, pl. 32, fig. 6). The margin between the fission rib and the posterior rib is gently sigmoid or convex; and at the tip of the posterior rib the margin is either narrowly rounded or it forms an angle of 10°–30°. The portion of this list in front of the fission rib is but slightly developed; its ventral margin is gently concave or almost straight, and its posterior width sometimes (Figure 97: 3) is only about half the length of the fission rib; in no case does its maximum width exceed the

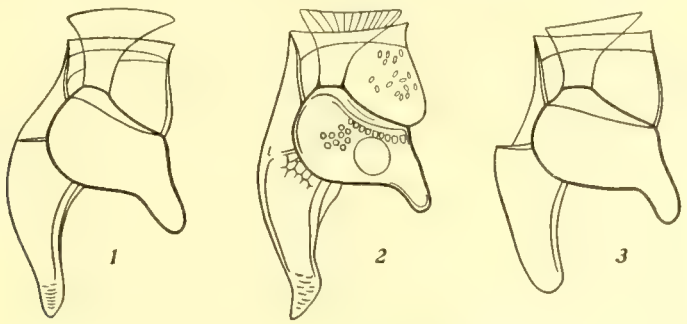

FIGURE 97.— *Histioneis biremis* Stein, left lateral view; in 2, structure of theca indicated and outline of nucleus shown. × 375. 1, 3, from Station 4722 (300–0 fathoms); 2, from Station 4724 (300–0 fathoms).

length of this rib; in relatively old specimens it may be reticulated (Murray and Whitting, 1899, pl. 32, fig. 6).

The thecal wall is areolate and porulate. The areoles along the anterior margin of the hypotheca differ in shape from the remaining ones, being flattened anteriorly. There is as a rule one pore in each areole. In the girdle a varying number of small, ovoidal phaeosomes are to be found.

The dimensions of five of our specimens, of the type specimen (Stein, 1883, pl. 22, fig. 13), and of the specimen figured by Murray and Whitting (1899, pl. 32, fig. 6) were measured.

Dimensions: — Our specimens: Length of body, 46.8–54.1 μ (average, 48.2 μ). Greatest depth of body, 44.5–54.5 μ (average, 46.8 μ). Total length, 101–114 μ (average, 109 μ). The size of the type specimen as drawn by Stein (1883, pl. 22,

fig. 13) is unknown. According to Stein's (1883) information about the magnifications of his figures given in an introductory remark to the explanations of the plates, this specimen had a total length of somewhere between 103 μ and 158 μ. Specimen figured by Murray and Whitting (1899, pl. 32, fig. 6): Length of body, 88.7 μ; greatest depth of body, 88.7 μ; total length, 193 μ.

Variations: — The shape and structure of the body and of the anterior cingular list are strikingly constant. The posterior cingular list, too, is usually very constant; however, in some specimens (Figure 97: 2) it is rather bulging. The shape and structure of the left sulcal list vary with age. The most variable character is the size. None of our specimens had a total length exceeding 114 μ, while in the specimen figured by Murray and Whitting (1899) the corresponding value was not less than 193 μ.

Comparisons: — Our specimens show a close agreement with the type, disregarding some evident inaccuracies in Stein's (1883, pl. 22, fig. 13) representation of the cingular lists. They differ strikingly in size from, but agree very closely in shape and structure with, the specimen of this species figured by Murray and Whitting (1899, pl. 32, fig. 6). In spite of the great variations in size, there can hardly be any doubt that the species as conceived in the present paper is a natural systematic unit.

Histioneis biremis presumably is most closely related to *H. highleyi.* This relationship is indicated by the posterodorsal spur-like process of the body, which is a unique feature of these two species, and by the great similarities in the cingular and sulcal lists. The first species is easily recognized from the last by the gentle, sigmoid curvature of the anterior margin of its hypotheca. These two species probably evolved from an ancestral form closely resembling *H. carinata.* This relationship is strongly suggested by the depressed shape of the body in the last species and by the striking similarities in the shape and structure of the cingular and sulcal lists and in the structure of the thecal wall. Of the two species, *H. biremis* and *H. highleyi,* the former is the more primitive. On the other hand, judging by the shape of the hypotheca, *H. highleyi* probably did not pass through a *biremis* stage, but these two species rather appear to have evolved independently from a common ancestral form.

Synonymy: — This species was established by Stein (1883) under the name of *Histioneis biremis,* a name also used by all the succeeding authors in this field.

Occurrence: — *Histioneis biremis* is recorded at nine of the 127 stations. There are 0, 0, 0, 2, 4, and 3 stations on the six lines of the Expedition. Of these nine stations, seven (4701, 4709, 4722, 4724, 4732, 4737, 4740) are in the South

Equatorial Drift; two (4742, 4743) are in the South Equatorial Current. At one station (4743) the species was taken in a surface haul. All the remaining records refer to hauls from 300–0 fathoms.

The temperature range of these nine stations at the surface was 72.0°–81.5°; the average was 77.2°.

The frequency is 1% at one station (4732), and less than 1% at the remaining stations.

Stein (1883) first recorded this species "aus der Südsee." Murray and Whitting (1899) found it at twelve localities in the Atlantic Ocean and the Caribbean Sea, between lat. 10° N. and lat. 31° N., and between long. 35° 30′ W. and long. 79° 80′ W. (Panama), in surface waters of 76° (67°–84°).

The species evidently is widely distributed but rare in tropical and subtropical waters. Judging by available data, the most noteworthy features of its occurrence in the region investigated by the Expedition are its rareness in surface waters and its absence from the coastal currents.

Histioneis highleyi Murray and Whitting

Figure 98; 95: 14

Histioneis highleii Murray & Whitting, 1899, p. 334, pl. 32, fig. 5, tab. 6, 8, 9. Lemmermann, 1899a, p. 374. Faria & Cunha, 1917, p. 79.
Histioneis highlei Okamura, 1912, p. 20, pl. 3, fig. 52.

Diagnosis: —Body (and hypotheca) asymmetrically Y-shaped, with posterior protuberance 1.5–2.5 times longer than deep; length: depth, 1.17–1.33: 1. Dorsally the transverse furrow is 0.54–0.65 the depth of body, five to eight times wider than ventrally, inclined dorsoposteriorly at 1°–10°, and very strongly concave. Distance from apex to posterior cingular list 0.09 the base of this list or even less. Anterior cingular list with very short stalk; its height 0.73–0.78 the depth of body; flaring widely with straight sides to funnel which is nearly twice as long dorsally as ventrally. Dorsal height of posterior cingular list 0.57–0.70 the depth of body. Left sulcal list with two main ribs, between which may be some short ribs and a submarginal rib; R_2 almost straight, inclined posteriorly at 1°–20°, and 0.19–0.39 the depth of body; R_3 marginal, strong, reticulated distally, 0.73–0.83 the depth of body, located on midline, and inclined posteroventrally at 10°–30°; margin between R_2 and R_3 gently sigmoid; posterior angle, 30°–40°. Theca areolate. Total length, 83–114 μ.

Widely distributed in warm seas.

Description: — This is a large, strikingly asymmetrical, Y-shaped or saddle-shaped species. The ratio between the length and the depth of the body is 1.23

(1.17–1.33): 1. The longitudinal axis (drawn through the apex and the posterior end of the posterior process) is inclined posterodorsally at 31° (28°–32°).

The epitheca is 0.17 (0.13–0.25) as deep as the hypotheca, slightly convex, highest in or near the center, and tilted dorsoposteriorly at 10°–25°. Dorsally the transverse furrow is 0.60 (0.54–0.65) the greatest depth of the body, five to eight times wider than ventrally, inclined dorsoposteriorly at 6° (1°–10°) to the horizontal plane, and very strongly concave. The distance from the apex to the posterior cingular list is only 0.09 the base of this list or even less. The shape of the hypotheca determines the shape of the body as a whole, since its anterior margin extends almost as far anteriorly as that of the transverse furrow. The anterior margin of the hypotheca has almost the same concavity as the transverse furrow; the ventroposterior margin is strongly sigmoid, convex anteriorly, and concave posteriorly; the dorsal margin is moderately or rather strongly concave. The anterodorsal shank of the hypotheca is less than half as large as the anteroventral, and about 1.5–2.5 times longer than high; the posterior process usually is somewhat larger than the anterodorsal shank but never as large as the anteroventral, and about 1.5–2.5 times longer than deep. All the three processes are well rounded distally.

The anterior cingular list has a short but distinct stalk and is about 4.5 (3.2–5.5) times wider distally than basally; its height is 0.75 (0.73–0.78) the greatest depth of the body, and its right side is strikingly lower than its left, but not ventrally notched. It flares widely with nearly straight sides, the ventral 0.5 the length of the dorsal and slightly concave. Its structure appears to be the same as in *Histioneis carinata*. The posterior cingular list, when fully developed, appears to be closed; it lacks structural differentiation except the dorsal and ventral ribs and the cross-rib; its dorsal height is 0.62 (0.57–0.70), its ventral height 0.37 (0.32–0.42) the greatest depth of the body; its frill is of moderate height, 0.25 (0.19–0.33) the dorsal rib, and it is but slightly if at all bulging. The left sulcal list is simple in shape and has two main ribs and between these, in older specimens, a few short ribs, faint reticulation, and a more or less developed submarginal rib. The fission rib is straight or gently sigmoid, 0.28 (0.19–0.39) the greatest depth of the body, and inclined posteriorly at 10° (1°–20°). The posterior rib is marginal, strong, reticulated distally, sometimes with a few short and weak secondary ribs (Murray and Whitting, 1899, pl. 32, fig. 5), 0.79 (0.73–0.83) the greatest depth of the body, slightly concave dorsally, located about midway between the transverse furrow and the posterior process, and inclined posteroventrally at 10°–30°. The margin between the fission rib and the pos-

terior rib is gently sigmoid, or almost straight; and at the tip of the posterior rib the margin forms an angle of 30°–40°. The portion of this list in front of the fission rib is but slightly developed; its ventral margin is gently concave or almost straight, and its posterior width sometimes is only half the length of the fission rib; in no case does its maximum width exceed the length of this rib.

The thecal wall is areolate (probably with scattered pores). In the girdle either a moderate number of large or numerous small phaeosomes are to be found (Murray and Whitting, 1899, pl. 32, fig. 5; Figure 98: 1). The phaeosomes are greenish in color; the large ones are spheroidal, the small ovoidal or spheroidal.

The dimensions of five of our specimens, of the type specimen (Murray and Whitting, 1899, pl. 32, fig. 5), and of the specimen figured by Okamura (1912, pl. 3, fig. 52) were measured.

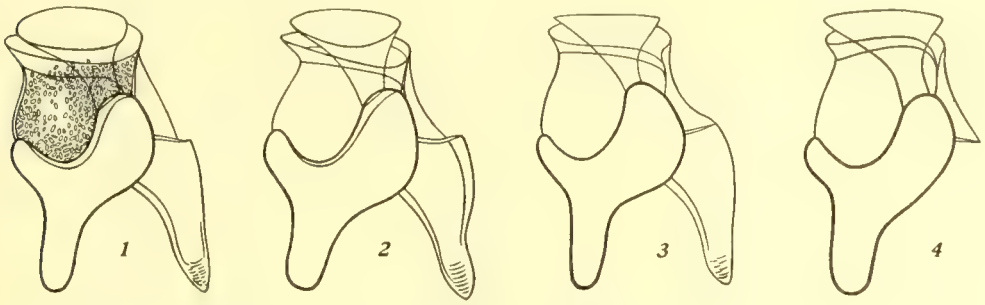

FIGURE 98.—*Histioneis highleyi* Murray and Whitting, right lateral view. × 375. 1, from Station 4705 (300–0 fathoms); 2, 3, 4, from Station 4722 (300–0 fathoms).

Dimensions: —Our specimens: Length of body, 62.2–66.5 μ (average, 64.2 μ). Greatest depth of body, 51.0–54.8 μ (average, 53.1 μ). Total length, 92–99 μ (average, 97 μ). Type specimen (Murray and Whitting, 1899, pl. 32, fig. 5): Length of body, 76.8 μ; greatest depth of body, 57.8 μ; total length, 114 μ. Specimen figured by Okamura (1912, pl. 3, fig. 52): Length of body, 51.4 μ; greatest depth of body, 46.1 μ; total length, 83 μ.

Variations: — This species is relatively constant. The most variable characteristics are the size, and the relative length and width of the three shanks of the Y-shaped body. The structure of its left sulcal list evidently varies with age: in relatively young specimens probably only the fission rib and the posterior rib are present; later the submarginal rib and the short ribs or even a faint reticulation (Okamura, 1912, pl. 3, fig. 52) appear. Another peculiarity worth mentioning in this connection is the great variation found in the size and the number of the phaeosomes.

Comparisons: — The specimens assigned by us to *Histioneis highleyi* agree very closely with the type as figured by Murray and Whitting (1899) as well as

with the specimen figured under this name by Okamura (1912). The most noteworthy difference between our specimens and those figured by these investigators is the size. The total length of the type specimen was 114 μ, that of the specimen figured by Okamura (1912), only 83 μ. Our specimens were of intermediary sizes, measuring 92–99 μ in length. The species as conceived in the present paper undoubtedly is a natural systematic unit.

Histioneis highleyi appears to be most closely related to *H. biremis*. This relationship is indicated by the posterior process of the body, which is a unique feature of these two species, and by the great similarities in the cingular and sulcal lists. The first species is readily recognized from the last by the strong concavity of the transverse furrow and of the anterior margin of the hypotheca (see also *H. biremis*, the section on comparisons).

Synonymy: — This species was established by Murray and Whitting (1899) under the name of *Histioneis highleii*, and the same name was used by all the succeeding authors in this field. It should be mentioned, however, that the specimen figured by Cleve (1902b, p. 30) as *Dinophysis intermedia*, sp. n., may belong to this species. Unfortunately, this specimen appears to be figured too poorly for certainty of specific assignment.

Occurrence: — *Histioneis highleyi* is recorded at six of the 127 stations. There are 0, 0, 0, 3, 3, and 0 stations on the six lines of the Expedition. Of these six stations, one (4699) is in the Easter Island Eddy; five (4705, 4707, 4721, 4722, 4730) are in the South Equatorial Drift. All records refer to hauls from 300–0 fathoms.

The temperature range of these six stations at the surface was 72°–79°; the average was 74.7°. The frequency is in all cases less than 1%.

Murray and Whitting (1899) recorded this species at six localities in the Atlantic, between lat. 24° N. and lat. 31° N. and between long. 35° W. and long. 51° W., in surface waters of 67°–77°. Faria and Cunha (1917) found it near Rio de Janeiro; Okamura (1912) in Japanese waters.

The species evidently is widely distributed but rare in tropical and subtropical waters. The most outstanding feature of its occurrence in the material of the Expedition is its absence from surface catches and from hauls made in the coastal currents.

4. Longicollis Group. Four species belong to this group. Of these, *Histioneis kofoidi* has been recorded only from the Mediterranean. The remaining ones have been treated in the present paper in the following order: — *H. longicollis*, *H. hyalina*, and *H. pacifica*, indicative of their systematic positions.

Histioneis longicollis Kofoid

Plate 20, fig. 5; Plate 21, fig. 5. Figure 95:7

Histioneis longicollis Kofoid, 1907a, p. 204, pl. 16, fig. 100.

Diagnosis: — Body obliquely subrotund in lateral outline, truncate anteriorly; length: depth, 0.89: 1. Dorsally the transverse furrow is 0.48 the depth of body, 2.4 times wider than ventrally, inclined dorsoposteriorly at 7°, and but slightly concave. Distance from apex to posterior cingular list 0.17 the base of this list. Anterior cingular list with long stalk; funnel with nearly straight sides, ventral scarcely inclined, dorsal abruptly and widely flaring; height 1.10 the depth of body. Dorsal height of posterior cingular list 0.91 the depth of body. Left sulcal list long, narrow, gently sigmoid ventrally, narrowly rounded posteriorly, gently concave dorsally; length of dorsal margin 1.36 the depth of body; anterior R_2 almost straight, inclined posteriorly at 35°–40°, and 0.28 the depth of body; posterior R_2 recurved dorsally toward middle of R_3 but does not join this rib; R_3 marginal, weak, extending along two thirds of dorsal margin of list, with a few short branches distally, located on midline, and inclined posteroventrally at 25°. Theca without structure. Total length, 72 μ.

Eastern tropical Pacific.

Description: — This is a fairly small, and relatively simple species, obliquely subrotund in lateral outline, truncate anteriorly. The ratio between the length and the depth of the body is about 0.89: 1. The longitudinal axis is deflected posterodorsally at about 25°.

The epitheca is about 0.12 as deep as the hypotheca, slightly convex, highest in or near the center, and subhorizontal. Dorsally the transverse furrow is about 0.48 the greatest depth of the body, about 2.4 times wider than ventrally, inclined dorsoposteriorly at about 7° to the horizontal plane, and but slightly concave. The distance from the apex to the posterior cingular list is about 0.17 the base of this list. The hypotheca is asymmetrical; the anterior margin is subhorizontal and gently concave; the ventral, posterior, and dorsal margins are well convex and confluent; the dorsal margin is somewhat more rounded than the ventral. In dorsoventral view the body is about 1.3 times longer than wide and widest in or near the middle; the outline of the hypotheca is ellipsoidal; the anterior portion of the body is rounded conical, with gently concave sides.

The anterior cingular list has a long, slender stalk and is about four times wider distally than basally; its height is about 1.10 the greatest depth of the body, and its right side is but slightly lower than its left; on the left side it has a sub-

marginal rib, to the middle of which a radial rib is attached. Its funnel is quite asymmetrical, the ventral side gradually and but slightly flaring, the dorsal abruptly and widely. The posterior cingular list is closed and lacks structural differentiation except the dorsal and ventral ribs and the cross-rib; its dorsal height is about 0.91, its ventral height about 0.80 the greatest depth of the body; its frill is of moderate height, about 0.23 the dorsal rib; and it is very slightly if at all bulging. The left sulcal list is flat, long, and narrow; its ventral margin is gently sigmoid, concave anteriorly, and convex posteriorly; posteriorly it is narrowly rounded, and its dorsal margin is gently concave. This list appears to lack structural differentiation except the fission rib and the posterior main rib. The anterior fission rib is almost straight, inclined posteriorly at 35°–40°, and about 0.28 the greatest depth of the body. The posterior fission rib is recurved dorsally toward the middle of the posterior main rib, but it does not join this rib; in the type specimen it has a very short distal branch. The posterior main rib is marginal, weak, extends along two thirds of the dorsal margin of the list, which is 1.36 the depth of the body, has a few short distal branches, is located on or near the midline, and is deflected posteroventrally at about 25°.

The thecal wall appears to lack pores and other structural differentiation. Numerous medium-sized, ovoidal phaeosomes were found in the girdle of the type specimen.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 20.3 μ. Greatest depth of body, 22.8 μ. Total length, 72 μ.

Comparisons: — The description given above is based on the type specimen.

The structurally closest-known relative of *Histioneis longicollis* is *H. kofoidi*. The former species differs from the latter mainly in the pronounced asymmetry of the hypotheca, in having the posterior main rib of the left sulcal list marginal instead of submarginal, and in the fact that the recurved posterior fission rib of this list does not join the posterior main rib. Other close relatives of *H. longicollis* are *H. hyalina* and *H. pacifica*, two species that are very readily distinguished from the first mentioned by the marked dorsoventral elongation of the body; *H. hyalina* is also characterized by having the dorsal margin of the left sulcal list strongly curled to the right, *H. pacifica* by having the posterior portion of this list spoon-shaped and furnished with a fairly highly developed reticulation. The close relationship of these four species is indicated by similarities in the structure of the thecal wall, and in the shape and structure of the cingular and sulcal lists; especially noteworthy in this connection is the fact that the posterior fission rib of

the left sulcal list is recurved dorsally. These four species may be regarded as comparatively primitive representatives of the line of evolution that led to the development of *H. pulchra* and related species. Regarding the specimen represented by Stein's (1883) Plate 22, figure 10, see *H. hyalina*, the section on comparisons.

Occurrence: — *Histioneis longicollis* is recorded at three of the 127 stations. One of these three stations (4680) is on the third, one (4711) on the fourth, and one (4741) on the sixth line of the Expedition; and all of them are in the South Equatorial Drift. At one station (4711) the species was taken in a haul from 300–0 fathoms; at the two remaining stations it was found in Salpa from surface waters.

The surface temperature of these three stations ranged from 68° to 80°; the average was 74.3°.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4711 of the Expedition, which thus is the type locality. The restriction of the record stations to the South Equatorial Drift is noteworthy.

Histioneis hyalina Kofoid and Michener

Plate 20, fig. 4. Figure 95: 5

Histioneis hyalina Kofoid & Michener, 1911, p. 296.

Diagnosis: — Body pyriform in lateral outline, somewhat higher dorsally than ventrally; length: depth, 0.61: 1. Dorsally the transverse furrow is 0.52 the depth of body, three times wider than ventrally, subhorizontal, and very slightly concave. Distance from apex to posterior cingular list 0.09 the base of this list. Anterior cingular list slender, with long stalk, flaring in distal 0.25; funnel with straight sides, slightly wider dorsally; height 0.95 the depth of body. Dorsal height of posterior cingular list 0.63 the depth of body. Left sulcal list relatively long and narrow, wedge-shaped posteriorly; length of dorsal margin 1.05 the depth of body; anterior R_2 almost straight, inclined posteriorly at 70°, and 0.56 the depth of body; posterior R_2 recurved dorsally, joining R_3 near middle; R_3 submarginal, weak, simple, extending along two thirds of dorsal margin of list, located midway between midline and antapex, and inclined posteroventrally at 10°–15°; narrow edge of list dorsally to R_3 recurved to the right. Theca without structure. Total length, 54 μ.

Eastern tropical Pacific.

Description: — The body of this species is small, depressed, and pyriform in

lateral outline. The ratio between the length and the depth of the body is about 0.61: 1. The longitudinal axis is deflected posterodorsally at 30°–40°.

The epitheca is about 0.10 as deep as the hypotheca, slightly convex, highest in or near the center, and inclined dorsoposteriorly at about 10°. Dorsally the transverse furrow is about 0.52 the greatest depth of the body, about three times wider than ventrally, subhorizontal, and very slightly concave. The distance from the apex to the posterior cingular list is about 0.09 the base of this list. The hypotheca is of short canoe-shape, distinctly higher dorsally than ventrally; its anterior margin is inclined dorsoanteriorly at about 10° and gently sigmoid, concave dorsally and convex ventrally; its dorsal, posterior, and ventral margins are confluent; dorsally it is rather strongly convex, posteroventrally it is flattened.

The anterior cingular list has a long, slender stalk and is about 3.5 times wider distally than basally; its height is about 0.95 the greatest depth of the body, and its right side is but slightly lower than its left; distally it has a few ribs anastomosing into a wide-meshed reticulum. The funnel has straight sides, flaring at the same level but about twice as much dorsally as ventrally. The posterior cingular list is closed and lacks structural differentiation except the dorsal and ventral ribs and the cross-rib (in the type specimen the frill also had a T-shaped rib on the left side, but this structure is probably not constant); its dorsal height is about 0.63, its ventral height about 0.57 the greatest depth of the body; its frill is of moderate height, about 0.37 the dorsal rib; and it is very slightly if at all bulging. The left sulcal list is relatively long and narrow; its ventral margin is almost straight anteriorly and posteriorly, and forms a very broadly rounded corner at the distal end of the fission rib; posteriorly it is narrowly rounded or subacute, and its dorsal margin is gently concave. This list appears to lack structural differentiation except the fission rib and the posterior main rib. The anterior fission rib is almost straight, inclined posteriorly at about 70°, and is about 0.56 the greatest depth of the body. The posterior fission rib is recurved dorsally and joins the posterior main rib near the middle of this rib. The posterior main rib is submarginal, weak, simple, extends along two thirds of the dorsal margin of the list, is located about midway between the midline and the antapex, and is deflected posteroventrally at about 10°–15°. An important character of this species is that the narrow portion of this list dorsally to the posterior main rib is recurved to the right.

The thecal wall appears to lack pores and other structural differentiation. A few small round phaeosomes were found in the girdle of the type specimen.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 13.3 μ. Greatest depth of body, 21.8 μ. Total length, 54 μ.

Comparisons: — Our description and figures are based on the type specimen.

The closest-known relatives of *Histioneis hyalina* probably are *H. longicollis* and *H. kofoidi*, from which it is easily distinguished by the strikingly depressed shape of its body (see *H. longicollis*, the section on comparisons). These three species appear to belong to the same line of evolution as *H. pulchra* and *H. cymbalaria*, but they have remained relatively undifferentiated in several respects, *e.g.*, in the structure of the left sulcal list. Among the specimens of this genus figured by previous investigators, the one represented by Stein (1883, pl. 22, fig. 10) as a young stage of *H. cymbalaria* resembles *H. hyalina* very strikingly. This specimen appears to be specifically different from *H. cymbalaria* (see *H. mitchellana*) as well as from *H. hyalina;* but, on the other hand, it undoubtedly is very closely related to the latter. Disregarding some differences, *e.g.*, the absence of a frill in the posterior cingular list and the dorsal and ventral splits in this list, which probably are due to Stein's overlooking some exceedingly delicate membranes, this specimen differs from *H. hyalina* in the shape and structure of the body, and in the structure of the left sulcal list. The posterior main rib of this list extends to the tip of the list and the posterior fission rib is longer and has short branches.

Occurrence: — *Histioneis hyalina* is recorded at only one (4720) of the 127 stations, on the fifth line of the Expedition in the South Equatorial Drift. The only specimen that was found occurred in a Salpa taken in surface waters at 76°.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4720 of the Expedition which thus is the type locality.

Histioneis pacifica, sp. nov.

Plate 20, fig. 8. Figure 95: 12

Diagnosis: — Body bean-shaped in lateral outline; length: depth, 0.65: 1; hypotheca of short canoe-shape, somewhat higher dorsally than ventrally. Dorsally the transverse furrow is 0.52 the depth of body, 3.5 times wider than ventrally, subhorizontal, and almost flat. Distance from apex to posterior cingular list 0.18 the base of this list. Anterior cingular list with stalk of moderate length, flaring in its distal 0.5 to a wide and very asymmetrical funnel with deep ventral notch, sides concave, wider dorsally, top sloping dextrally, with some ventral inclination, about 45°; its height 0.78 the depth of body. Dorsal height of posterior

cingular list 0.51 the depth of body. Left sulcal list fairly long and narrow, well rounded posteriorly, gently concave dorsally; spoon-shaped posteriorly, portion dorsally to R_3 curled to the right; anterior R_2 almost straight, inclined posteriorly at 50°–60°, and 0.34 the depth of body; posterior R_2 recurved dorsally, joining R_3 near middle, with few short branches; R_3 submarginal, fairly weak, gently sigmoid, 0.79 the depth of body, forming branches and irregular reticulum posteriorly, located midway between midline and antapex, and inclined posteroventrally at 5°–10°. Theca with pores only. Total length, 63 μ.

Eastern tropical Pacific.

Description: — The body of this species is small, depressed, and bean-shaped in lateral outline. The ratio between the length and the depth of the body is about 0.65: 1. The longitudinal axis is deflected posterodorsally at 25°–30°.

The epitheca is about 0.14 as deep as the hypotheca, flat, and subhorizontal. Dorsally the transverse furrow is about 0.52 the greatest depth of the body, about 3.5 times wider than ventrally, subhorizontal, and flat or very slightly concave. The distance from the apex to the posterior cingular list is about 0.18 the base of this list. The hypotheca is of short canoe-shape, distinctly higher dorsally than ventrally; its anterior margin is inclined dorsoanteriorly at about 10° and well concave; its dorsal, posterior, and ventral margins are well convex and confluent; the convexity is most pronounced on the dorsal side. In dorsoventral view the body is subcircular; the ratio between the length and the width is about 0.83: 1.

The anterior cingular list has a stalk of moderate length and is about four times wider distally than basally; it flares widely and asymmetrically in the distal 0.5, with concave sides, about twice as wide dorsally as ventrally; the ventral notch is well defined and the top inclines dextrally rather steeply (45°) with less of a ventral component than usual; its height is about 0.78 the greatest depth of the body, and its right side considerably lower than its left; distally it has a few ribs anastomosing into an irregular, wide-meshed reticulum. The posterior cingular list is closed and lacks structural differentiation except the dorsal and ventral ribs and the cross-rib; its dorsal height is about 0.51, its ventral height about 0.53 the greatest depth of the body; the frill is of moderate height, about 0.50 the dorsal rib, and it is very slightly if at all bulging. The left sulcal list is fairly long and narrow; its ventral margin is almost straight, slightly convex in the middle; posteriorly it is well rounded, and its dorsal margin is gently concave; posteriorly it is spoon-shaped, the portion dorsally to the posterior main rib being curled to the right. The list has two main ribs and in front of the fission rib a few branched and irregularly anastomosing ribs. The anterior fission rib is almost straight, inclined

posteriorly at 50°–60°, and 0.34 the greatest depth of the body. The posterior fission rib is recurved dorsally, joins the posterior main rib near the middle of this rib, and has a few short branches; in the type specimen one of these joins the posterior main rib somewhat proximally to the middle. The posterior main rib is submarginal, fairly weak, gently sigmoid, extends to the posterior margin of the list, is about 0.79 the greatest depth of the body, located about midway between the midline and the antapex, inclined posteroventrally at 5°–10°, and forms branches and an irregular reticulum posteriorly.

The thecal wall lacks structural differentiation except pores. On the hypotheca there are a few scattered pores and a dense row of pores along the girdle. In the transverse furrow there are two dense rows of pores, one along the posterior cingular list and one along the sagittal suture. Phaeosomes were not observed.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 18.6 μ. Greatest depth of body, 28.8 μ. Total length, 63 μ.

Comparisons: — The description given above is based on the type specimen.

Histioneis pacifica is probably most closely related to *H. hyalina*. This relationship is indicated by the similarities in the shape of the body, and in the shape and structure of the posterior cingular list and of the left sulcal list; for instance, the transverse furrow is flat and subhorizontal, the hypotheca is of short canoe-shape, the frill of the posterior cingular list is rather wide, and the posterior fission rib of the left sulcal list is recurved dorsally and joins the posterior main rib. The first species is readily distinguished from the last by the shorter stalk of its anterior cingular list and by the fact that the posterior main rib of its left sulcal list extends to the posterior edge of this list and has branches and an irregular reticulation posteriorly. Furthermore, *H. pacifica* is in some respects intermediate between the relatively simple *H. hyalina* and *H. longicollis* on the one hand and the highly differentiated *H. pulchra* on the other; for instance, the posterior portion of its left sulcal list is spoon-shaped, the posterodorsal portion of this list being rather strikingly curled to the right.

Occurrence: — *Histioneis pacifica* is recorded at two of the 127 stations. One of these two stations (4733) is on the fifth, the other (4741, the type locality) on the sixth line of the Expedition; and both are in the South Equatorial Drift. Only two specimens were found, both occurring in Salpa taken in surface waters. The surface temperature of these two stations was 80°.

5. Pulchra Group. One of the six species of this group, viz., *Histioneis cymbalaria*, was not found by us. The remaining species have been treated in the

following order: — *H. gubernans, H. striata, H. pulchra, H. mitchellana,* and *H. panda.*

Histioneis gubernans Schütt

Histioneis gubernans Schütt, 1895, pl. 5, fig. 23; 1896, p. 29, fig. 42A. Lemmermann, 1899a, p. 374. Zacharias, 1906, p. 509, 518. Kofoid & Michener, 1911, p. 296, 299, 300.

Since no drawings or records of variations were made of the specimens of this species found in the material of the Expedition, we do not give any diagnosis or description, but refer the reader to Schütt's (1895) figure of the type specimen (this figure is reproduced in Schütt, 1896). With regard to relationships, see *Histioneis striata* and *H. reginella,* the sections on comparisons.

Occurrence: — *Histioneis gubernans* is recorded at five of the 127 stations. There are 0, 0, 1, 1, 3, 0 stations on the six lines of the Expedition, all of them (4679, 4711, 4730, 4733, 4737) located in the South Equatorial Drift. At one station the species was found in a Salpa taken in surface waters; the four remaining records refer to hauls from 300–0 fathoms. The temperature range of these five stations at the surface was 69.0°–81.5°; the average was 76.9°. The frequency is in each case less than 1%.

Schütt (1895), who was the first to record this species, does not give any information as to the type locality; however, he probably obtained his material either at Naples or in the warm region of the Atlantic Ocean. Zacharias (1906) found this species in the Adriatic Sea. The most outstanding feature about the distribution of this form in the region investigated by the Expedition is the restriction of all the record stations to the South Equatorial Drift.

Histioneis striata Kofoid and Michener

Plate 20, fig. 6. Figure 96: 1

Histioneis striata Kofoid & Michener, 1911, p. 300.

Diagnosis: — Body subrotund in lateral outline, truncate anteriorly; length: depth, 0.94: 1. Dorsally the transverse furrow is 0.43 the depth of body, three times wider than ventrally, subhorizontal, and moderately concave. Distance from apex to posterior cingular list 0.16 the base of this list. Anterior cingular list with long stalk, flaring gradually in its distal 0.33 in the slightly developed, slightly asymmetrical funnel; its height 1.21 the depth of body. Dorsal height of posterior cingular list 0.87 the depth of body; frill 0.50 the dorsal rib, with three to six ribs on each valve. Left sulcal list rather broad, gently convex ventrally, narrowly rounded posteriorly, and strongly concave dorsally; anterior R_2 straight, subhorizontal, 0.64 the depth of body; posterior R_2 recurved to posterior end of

list, with a few short branches and a cross-rib to middle of R_3; R_3 submarginal, weak, subequal to depth of body, strongly sigmoid, with some short branches, located somewhat ventrally to midline, inclined posteroventrally at 40°–50°; a submarginal rib with some short branches along anterior portion of ventral margin; portion dorsally to R_3 curled to the right. Theca with pores only. Total length, 43 μ.

Eastern tropical Pacific.

Description: — This species is very small, with the body subrotund in lateral outline, truncate anteriorly, and deepest somewhat behind the girdle. The ratio between the length and the depth of the body is about 0.94: 1. The longitudinal axis is deflected posterodorsally at about 20°.

The epitheca is about 0.15 as deep as the hypotheca, gently convex, highest in the center, and subhorizontal. Dorsally the transverse furrow is about 0.43 the greatest depth of the body, about three times wider than ventrally, subhorizontal, and moderately concave. The distance from the apex to the posterior cingular list is about 0.16 the base of this list. The hypotheca is subsymmetrical; the anterior margin is inclined dorsoanteriorly at about 10° and gently concave; the ventral, posterior, and dorsal margins are well convex and confluent, but the convexity is somewhat more pronounced dorsally than ventrally.

The anterior cingular list has a long, slender stalk and is about 2.5 times wider distally than basally; it flares in its distal 0.33 gradually into a feebly developed, slightly asymmetrical funnel with somewhat more dorsal than ventral flare; it has no ventral notch and its anterior end slopes dextroventrally; its height is about 1.21 the greatest depth of the body, and its right side is but slightly lower than its left; distally it has a few short longitudinal ribs. The posterior cingular list is closed but not inflated; its dorsal and ventral heights are subequal and about 0.87 the greatest depth of the body; its frill is fairly high, about 0.50 the dorsal rib, and furnished with three to six longitudinal ribs on each valve. The left sulcal list is rather broad, gently convex ventrally, narrowly rounded posteriorly, and strongly concave dorsally. The anterior fission rib is straight, subhorizontal, and about 0.64 the greatest depth of the body. The posterior fission rib is recurved to the posterior end of the list and has some short branches, most of which are on its ventral side, and a ventral branch that joins the posterior main rib near the middle of this rib. The posterior main rib is submarginal, rather weak, subequal to the greatest depth of the body, strongly sigmoid, concave anteriorly and convex posteriorly, with some short branches on its ventral side, located somewhat ventrally to the midline, and inclined posteroventrally at about 40°–50°. A sub-

marginal rib with some short ventral branches runs along the anterior portion of the ventral margin of this list, ending near the posterior fission rib. The portion of the list dorsally to the posterior main rib is curled to the right.

The thecal wall is smooth. The hypotheca has a row of about seven pores along the girdle and a transverse row of about three pores midway below. A moderate number of medium-sized, ovoidal phaeosomes were found in the girdle of the type specimen.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 15.7 μ. Greatest depth of body, 16.8 μ. Total length, 43 μ.

Comparisons: — The description given above is based on the type specimen.

Histioneis striata is, next to *H. gubernans*, the most primitive member of the PULCHRA group. These two species resemble each other in being small, in having the hypotheca subcircular and the transverse furrow subhorizontal and gently concave, in the shape and structure of the posterior cingular list, and in the structure of the left sulcal list. The former species differs from the latter in the long stalk and narrow anterior opening of its anterior cingular list and in the fact that the dorsal margin of its left sulcal list is strongly curled to the right in its entire length.

Occurrence: — *Histioneis striata* is recorded at two of the 127 stations. These two stations (4720, 4725) are located on the fifth line of the Expedition and in the South Equatorial Drift. Only two specimens were found, both occurring in Salpa taken in surface waters. The surface temperatures of these two stations were 76° and 77°, respectively.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4720 of the Expedition, which thus is the type locality. The restriction of the record stations to the South Equatorial Drift is noteworthy.

HISTIONEIS PULCHRA Kofoid

Plate **21**, fig. 4, 7; Plate **23**, fig. 2. Figure 96: 2; 99

Histioneis pulchra KOFOID, 1907a, p. 205, pl. 16, fig. 99. KOFOID & MICHENER, 1911, p. 298.

Diagnosis: — Body saddle-shaped in lateral outline, strikingly higher dorsally than ventrally; length: depth, 0.44–0.46: 1. Dorsally the transverse furrow is 0.62–0.66 the depth of body, eight times wider than ventrally, inclined dorsoanteriorly at 20°–25°, and strongly concave. Distance from apex to posterior cingular list 0.09–0.12 the base of this list. Anterior cingular list with fairly long

stalk, flaring in its distal 0.5 in a stout subsymmetrical funnel with slightly concave sides, no notch, and slightly inclined top; its height 1.06–1.15 the depth of body. Dorsal height of posterior cingular list 0.74–0.86 the depth of body; frill high, 0.77–0.79 the dorsal rib, with a moderate number of irregular, partly anastomosing longitudinal ribs. Left sulcal list tongue-shaped, narrowly rounded posteriorly; anterior R_2 gently sigmoid, inclined posteriorly at 50°–60°, and 0.68–0.75 the depth of body; posterior R_2 recurved dorsally, joining R_3 somewhat in front of middle; portion of list behind posterior R_2 coarsely reticulated; R_3 runs somewhat inside dorsal margin of list, weak, 1.10–1.14 the depth of body, located somewhat ventrally to antapex, inclined posteroventrally at 10°–20°; portion dorsally to R_3 curled to the right. Theca with pores only. Total length, 131–136 μ.

Eastern tropical and subtropical Pacific.

Description: — This is a large species with body saddle-shaped in lateral outline, strikingly higher dorsally than ventrally. The ratio between the length and the depth of the body is about 0.44–0.46: 1. The longitudinal axis is deflected posterodorsally at about 40°–45°.

The epitheca is about 0.11–0.12 as deep as the hypotheca, gently convex, highest in the center, and subhorizontal. Dorsally the transverse furrow is 0.62–0.66 the greatest depth of the body, about eight times wider than ventrally, inclined dorsoanteriorly at 20°–25° to the horizontal plane, and strongly concave. The distance from the apex to the posterior cingular list is 0.09–0.12 the base of this list. The anterior margin of the hypotheca is inclined dorsoanteriorly at 20°–25° to the horizontal plane, and well, but sometimes somewhat irregularly concave; posteroventrally the hypotheca is flattened, gently convex; posterodorsally and dorsally it is strongly convex, subcircular. Seen in dorsoventral view, the body is subcircular posteriorly and rounded conical anteriorly.

The anterior cingular list has a fairly long stalk, and it is 4.6–6.5 times wider distally than proximally; its height is 1.06–1.15 the greatest depth of the body, and its right side is but slightly if at all lower than its left. It flares in its distal 0.5 at first gradually, then abruptly, into a subsymmetrical funnel with slightly concave sides, subequal dorsal and ventral extent, no notch, and slight dextroventral inclination. Distally it has a moderate, but varying number of irregular and partly anastomosing ribs. The posterior cingular list is closed and has basally on both sides the rudiment of a lateral pouch; its dorsal and ventral heights are subequal and 0.74–0.86 the depth of the body; its frill is dorsally about 0.77–0.79 the dorsal rib, of moderate height in the middle, and has a moderate but varying number of irregular, partly anastomosing longitudinal ribs. The left sulcal list is

tongue-shaped and relatively large; its ventral margin either is irregularly undulating (Plate 23, fig. 2), or it is almost straight anteriorly and posteriorly, and broadly rounded at the anterior fission rib; the posterior portion of this list is narrowly rounded; the dorsal margin is gently concave or broadly indented near the middle. From the proximal end of the anterior main rib a fairly long, simple or branched rib runs in a posteroventral direction. The anterior fission rib is gently sigmoid, inclined posteriorly at 50°–60°, and 0.68–0.75 the greatest depth of the body; either it is simple, or it has on its ventral side some irregular, partly anastomosing branches. The posterior fission rib is recurved dorsally and joins the posterior main rib somewhat in front of the middle of this rib. The portion of the list behind the posterior fission rib is coarsely reticulated. The posterior main rib runs somewhat inside the dorsal margin of the list, is weak, about 1.10–1.14 the greatest depth of the body, extends nearly to the tip of the list, is bent ventrally at the place where it is joined by the posterior fission rib, located somewhat ventrally to the antapex, and inclined posteroventrally at 10°–20°. The portion of the list dorsally to the posterior rib is curled to the right, forms near the middle a fairly large, narrowly rounded lobe, and might have its edge reënforced by a fine rib, from which some branches may arise.

The thecal wall is smooth. The hypotheca has a close-set row of pores along the girdle and a moderate number of scattered pores. In the transverse furrow there is a close-set row of pores along the posterior cingular list. A varying number of small, ovoidal phaeosomes are to be found in the girdle. As to the colors of this species, see Plate 23, figure 2.

The dimensions of two specimens were measured.

Dimensions: — Length of body, 22.4–23.1 μ (type, 22.4 μ). Greatest depth of body, 49.7–50.1 μ. Total length, 131–136 μ (type, 136 μ).

Variations: — This species appears to be relatively constant. The most variable of its characters are the relative width of the distal opening of the anterior cingular list and the structure of this list and of the frill of the posterior cingular list. The anterior fission rib sometimes is simple, sometimes more or less branched on its ventral side.

Comparisons: — The description given above is based on the type specimen.

Histioneis pulchra occupies morphologically and probably also phylogenetically an intermediate position between *H. kofoidi* — *H. longicollis* — *H. hyalina* on the one hand and *H. cymbalaria* (Stein, 1883, pl. 22, fig. 7) — *H. mitchellana* on the other. In *H. kofoidi* the body is subsymmetrical, subrotund, and truncate anteriorly; in *H. longicollis* it is subrotund, higher dorsally than ventrally, and

truncate anteriorly; in *H. hyalina* it is pear-shaped, elongated dorsoventrally, higher dorsally than ventrally, and its transverse furrow is flat; in *H. pulchra*, *H. cymbalaria*, and *H. mitchellana* it is saddle- or canoe-shaped, higher dorsally than ventrally, with the transverse furrow strongly concave. The structure of the cingular lists is simple in *H. kofoidi*, *H. longicollis*, and *H. hyalina*, of moderate complexity in *H. pulchra*, and very elaborate in *H. cymbalaria* and *H. mitchellana*. The frill of the posterior cingular list is rather narrow in *H. longicollis*, of moderate width in *H. hyalina*, and wide in *H. pulchra*, *H. cymbalaria*, and *H. mitchellana*.

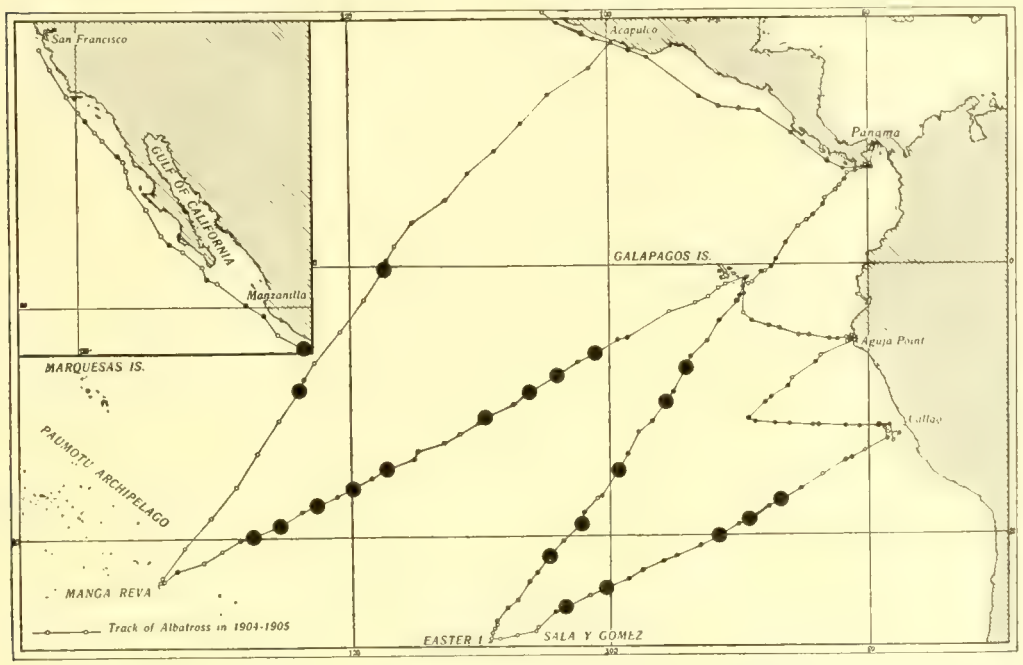

FIGURE 99.— Occurrence of *Histioneis pulchra* Kofoid. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

The structure of the left sulcal list is simple in *H. kofoidi*, *H. longicollis*, and *H. hyalina*, fairly complex in *H. pulchra*, and very elaborate in *H. cymbalaria* and *H. mitchellana*. The posterior main rib of this list is marginal in *H. longicollis;* in *H. kofoidi* and *H. hyalina* it is submarginal, and the narrow portion of the list dorsally to it is curled to the right in *H. hyalina*. In *H. pulchra*, *H. cymbalaria*, and *H. mitchellana* the portion dorsally to this rib is not only curled to the right, but it is relatively wide in the middle, where it forms a narrowly rounded lobe, which is especially well defined in *H. cymbalaria* and *H. mitchellana*. Observe also the progressive development in the relative length and the direction of the anterior fission rib in these six species. The outstanding characteristic of these

species is the shape of the posterior fission rib. See also *H. pacifica* and *H. panda*, the sections on comparisons.

Occurrence: — *Histioneis pulchra* is recorded at twenty-two of the 127 stations. There are 1, 0, 5, 5, 9, and 2 stations on the six lines of the Expedition. Of these twenty-two stations, one (4590) is in the Mexican Current; three (4689, 4691, 4699) are in the Easter Island Eddy; seventeen (4679, 4681, 4683, 4701, 4705, 4709, 4711, 4719, 4721, 4722, 4724, 4730, 4732, 4734, 4736, 4737, 4740) are in the South Equatorial Drift; and one (4742) is in the South Equatorial Current. At one station (4681) the species was taken in a haul from 800–0 fathoms; at one station (4737) it was taken in hauls both from 100–0 fathoms and 300–0 fathoms; all the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these twenty-two stations at the surface was 68°–83°; the average was 75.6°.

The frequency is less than 1% except at Station 4590 where it is 1%.

Although the species has been recorded only from the material of the Expedition, we have found it to be the most common representative of this genus in the eastern tropical Pacific. The most striking features of its occurrence in the eastern Pacific, according to our data, are its predominance in the South Equatorial Drift and the Easter Island Eddy and its absence from surface waters.

Histioneis mitchellana Murray and Whitting

Plate 21, fig. 2. Figure 96: 4; 100

Histioneis mitchellana Murray & Whitting, 1899, p. 333, 335, pl. 33, fig. 3, tab. 1, 6, 8, 9. Lemmermann, 1899a, p. 374. Kofoid, 1907a, p. 205.
Histioneis mitchelliana Schröder, 1906a, p. 329.

Diagnosis: — Body canoe-shaped, higher dorsally than ventrally; length: depth, 0.32–0.53: 1. Dorsally the transverse furrow is 0.60–0.65 the depth of body, 8–11 times wider than ventrally, inclined dorsoanteriorly at 1°–15° or dorsoposteriorly at 1°–3°, and fairly strongly concave. Distance from apex to posterior cingular list 0.11–0.20 the base of this list. Anterior cingular list with fairly long stalk, flaring abruptly and asymmetrically in its distal 0.33 into a very wide funnel without notch and with almost symmetrical, slightly sloping top. Dorsal height of posterior cingular list 0.87–1.10 the depth of body; frill about half as high as list or even somewhat more, finely reticulated. Left sulcal list tongue-shaped, rounded posteriorly, with flap-like lobe curled to the right near middle of dorsal margin, finely reticulated; anterior R_2 gently sigmoid, directed posteriorly, 0.86–0.95 the depth of body; posterior R_2 recurved dorsally, joining

R_3 near anterior margin of dorsal flap-like lobe; R_3 located somewhat dorsally to antapex, its distal portion often broken up into a reticulum; length of list, 0.88–1.08 the depth of body. Theca with pores only. Total length, 110–150 μ.

Widely distributed in tropical and subtropical seas.

Description: — This is a large species with body canoe-shaped in lateral outline, somewhat higher dorsally than ventrally. The ratio between the length and the depth of the body is 0.40 (0.32–0.53): 1. The longitudinal axis is deflected posterodorsally at about 30°–40°.

The epitheca is 0.09 (0.08–0.12) as deep as the hypotheca, gently convex, highest in or near the center, and either subhorizontal or inclined dorsoposteriorly at about 5°–10°. Dorsally the transverse furrow is 0.62 (0.60–0.65) the greatest depth of the body, 8–11 times wider than ventrally, fairly strongly concave and either subhorizontal, or inclined dorsoanteriorly at 1°–15° or dorsoposteriorly at 1°–3° to the horizontal plane. The distance from the apex to the posterior cingular list is 0.16 (0.11–0.20) the base of this list. The anterior margin of the hypotheca is well concave, and either subhorizontal, or inclined dorsoanteriorly at 1°–15° or dorsoposteriorly at 1°–5° to the horizontal plane; the ventral margin is well rounded; the posterior margin is flat and confluent with the ventral and dorsal margins; the dorsal margin is strongly convex, or its anterior portion is flattened and forms a well-rounded corner with its posterior portion. Seen in dorsoventral view the body is subcircular posteriorly and rounded conical anteriorly.

The anterior cingular list has a fairly long stalk and is 10 (8–13) times wider distally than proximally; its height is 1.27 (1.18–1.33) the greatest depth of the body, and its right side is but slightly if at all lower than its left. It flares symmetrically and gradually in its middle 0.33 and abruptly and asymmetrically in its distal 0.33 into a funnel with concave sides, with nearly three times as much dorsal as ventral flare, no ventral notch, and an almost symmetrical top with slight ventral inclination. Its distal half is finely reticulated, and its distal margin may have some short and fine spinules. The posterior cingular list is closed; when seen in dorsoventral view (Murray and Whitting, 1899, pl. 33, fig. 3b) it is rather inflated in the middle and constricted near its anterior end; the dorsal height is 0.99 (0.87–1.10), the ventral height 0.87 (0.80–0.91) the greatest depth of the body; the frill is about half as high as this list, or even slightly more, and finely reticulated; the anterior edge may have some fine and rather short spinules. The left sulcal list is tongue-shaped, rounded posteriorly, and finely reticulated; its ventral margin is either moderately convex (Murray and Whitting, 1899, pl. 33, fig. 3a), or gently convex in front of the anterior fission rib and gently concave

at the distal end of this rib (Plate 21, fig. 2), or irregularly undulating (Figure 96:4); its dorsal margin is either almost straight, or somewhat irregular and undulating; in or somewhat in front of the middle of the dorsal margin, it has a flap-like lobe, which is curled to the right, subcircular or tongue-shaped, and whose dorsoventral width is 0.36 (0.34–0.38) the greatest depth of the body. The anterior fission rib is gently sigmoid, directed posteriorly, and 0.91 (0.86–0.95) the greatest depth of the body. The posterior fission rib is recurved dorsally and joins the posterior main rib near the anterior margin of the dorsal, flap-like lobe. The posterior main rib is located somewhat dorsally to the antapex, deflected somewhat posteroventrally, and either extends to near the posterior end of the list (Murray and Whitting, 1899, pl. 33, fig. 3a), or its distal portion is broken up into a reticulum (Plate 21, fig. 2). The length of this list is 0.98 (0.88–1.08) the greatest depth of the body.

The thecal wall is smooth. The hypotheca has a close-set row of pores along the girdle and a varying number of scattered pores. In the transverse furrow there is a close-set row of pores along the posterior cingular list. A varying number of large, round phaeosomes are to be found in the girdle.

The dimensions of two of our specimens and of the type specimen (Murray and Whitting, 1899) were measured.

Dimensions: — Our specimens: Length of body, 18.9–22.2 μ. Greatest depth of body, 42.1–55.3 μ. Total length, 112–150 μ. Type specimen (Murray and Whitting, 1899, pl. 33, fig. 3a): Length of body, 15.3 μ. Greatest depth of body, 48.4 μ. Total length, 110 μ.

Variations: — This species appears to be relatively constant. The most variable characters are the size of the organism, the course of the cross-rib of the posterior cingular list, the shape of the ventral margin of the left sulcal list, and the shape and relative size of the flap-like dorsal lobe of the last-mentioned list.

Comparisons: — The specimens assigned by us to *Histioneis mitchellana* agree very closely with the type as figured by Murray and Whitting (1899), and the systematic unity of this species, as conceived in the present paper, can be regarded as certain.

Histioneis mitchellana is very closely related to *H. cymbalaria* Stein (1883, pl. 22, fig. 7). It is easily recognized from this species by the fact that its body is more elongated dorsoventrally, by the greater distal width of the anterior cingular list, and by the course of the posterior fission rib of the left sulcal list. It should be mentioned in this connection that, according to our opinion, all the three specimens figured by Stein (1883, pl. 22, fig. 7–10) as *H. cymbalaria* are

specifically different from each other, and that the specimen represented by his Plate 22, figure 7, should be regarded as the type of *H. cymbalaria*. Other relatives of *H. mitchellana* are *H. kofoidi*, *H. longicollis*, *H. hyalina*, and *H. pulchra* (see the last species, the section on comparisons).

Synonymy: — This species was established by Murray and Whitting (1899) under the name of *Histioneis mitchellana*. Later Schröder (1906a) used the designation *H. mitchelliana*.

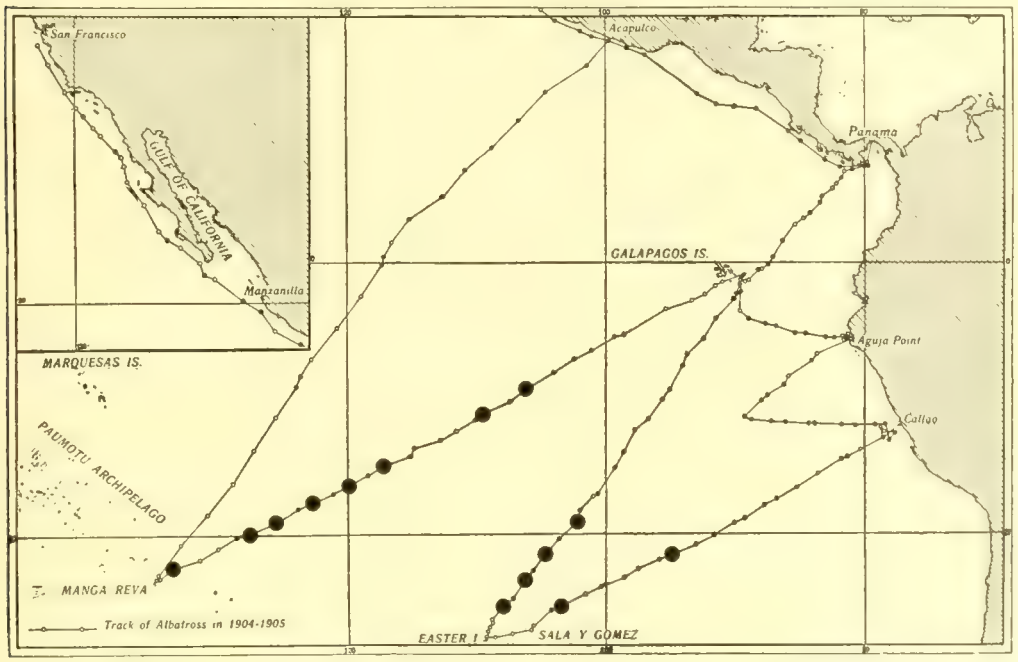

FIGURE 100.— Occurrence of *Histioneis mitchellana* Murray and Whitting. Large, solid circles indicate records from vertical hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

Occurrence: — *Histioneis mitchellana* is recorded at fourteen of the 127 stations. There are 0, 0, 2, 4, 8, and 0 stations on the six lines of the Expedition. Of these fourteen stations, four (4691, 4695, 4697, 4699) are in the Easter Island Eddy; and ten (4685, 4701, 4722, 4724, 4730, 4732, 4734, 4736, 4737, 4739) are in the South Equatorial Drift. At one station (4737) the species was taken in a haul from 100–0 fathoms as well as in a haul from 300–0 fathoms. All other records refer to hauls from 300–0 fathoms only.

The temperature range of these fourteen stations at the surface was 72.0°–81.5°; the average was 76.8°.

The frequency is less than 1% except at two stations (4730, 4732), where it is 1%.

Murray and Whitting (1899), who were the first to record this species, found

it at twelve stations in the Atlantic Ocean and the Caribbean Sea, between lat. 15° 50′ N. and lat. 34° 30′ N., and between long. 30° W. and long. 70° W., in surface waters of 64°–81°. Schröder (1906a) found it in the Indian Ocean, between Ceylon and Singapore in surface collections.

This species is eupelagic and widely distributed in tropical and subtropical seas. The most outstanding features of its occurrence in the Eastern Pacific, according to our data, are its absence from surface waters and its restriction to the Easter Island Eddy and the South Equatorial Drift. However, all records from other seas are from surface collections, and the limitation in our records to vertical hauls is either a coincidence or an indication of relatively greater abundance in deeper waters rather than an exclusion from the surface.

Histioneis panda Kofoid and Michener

Figure 85: 1; 95: 9

Histioneis panda Kofoid & Michener, 1911, p. 298.

Diagnosis: — Body sausage-shaped, slightly higher dorsally than ventrally; length: depth, 0.36: 1. Dorsally the transverse furrow is 0.74 the depth of body, 9.5 times wider than ventrally, inclined dorsoanteriorly at 25°–30°, and strongly concave. Distance from apex to posterior cingular list 0.04 the base of this list. Anterior cingular list with long stalk; it flares in its distal 0.35 in a gradually increasing rate with slight concavity. Its asymmetry is marked by an unusual degree of dextral torsion, steep dextroventral inclination of the top, and deep acute dextroventral notch; its height is subequal to depth of body. Posterior cingular list large and forms lateral pouches of moderate size; its dorsal height 0.73 the depth of body; frill broad, 0.67 the dorsal rib, with narrow secondary frill and faint reticulation. Left sulcal list subtriangular posteriorly; anterior R_2 gently curved, directed posteriorly, 0.34 the depth of body; posterior R_2 recurved dorsally, joining R_3 somewhat behind middle, its distal half with short branches; R_3 runs at a distance from dorsal margin of list 0.13 the depth of body, fairly weak, 0.59 the depth of body, its distal half with short branches, located midway between midline and antapex, inclined posteroventrally at 10°–15°; portion dorsally to R_3 curled to the right in the middle; posterior angle, 70°. Theca with pores only. Total length, 79 μ.

Eastern tropical Pacific.

Description: — This species is of medium size, sausage-shaped in lateral outline, and slightly higher dorsally than ventrally. The ratio between the length

and the depth of the body is about 0.36: 1. The longitudinal axis is deflected posterodorsally at about 40°–45°.

The epitheca is about 0.07 as deep as the hypotheca, gently convex, highest in or near the center, and subhorizontal. Dorsally the transverse furrow is about 0.74 the greatest depth of the body, about 9.5 times wider than ventrally, inclined dorsoanteriorly at 25°–30° to the horizontal plane, and strongly concave. The distance from the apex to the posterior cingular list is about 0.04 the base of this list. The anterior margin of the hypotheca is inclined dorsoanteriorly at 25°–30° to the horizontal plane, and well concave, forming almost an arc of a circle; the dorsal, posterior, and ventral margins are confluent and convex, the convexity more pronounced dorsally than ventrally.

The anterior cingular list has a long slender stalk and is five to six times wider distally than proximally; its height is subequal to the greatest depth of the body. It flares in its distal 0.35 gradually, with a slight concavity of the sides as seen in lateral view of the body, with a marked and unusual torsion of the structure so that the acute ventral notch is carried to the right nearly 80° from the midventral line and with a steep dextroventral inclination of the top. On the left valve it has distally a faint reticulation of moderate-sized meshes; on the right valve it almost lacks structure. The posterior cingular list is closed and large, forms on both sides a lateral pouch of moderate size, is strikingly contracted distally, and has an asymmetry paralleling that of the anterior list; its dorsal height is about 0.73, its ventral height about 0.61 the greatest depth of the body; its frill is broad, about 0.67 the dorsal rib; the cross-rib is simple but has a strikingly undulating course; it has a narrow secondary frill, bordered by a well-developed cross-rib, and a faint reticulation of the same kind as that of the anterior cingular list. The left sulcal list is narrow anteriorly and subtriangular posteriorly, with only two ribs. The anterior fission rib is gently concave posteriorly, deflected posteriorly at about 85°, and about 0.34 the greatest depth of the body. The posterior fission rib is recurved dorsally, joining the posterior main rib somewhat behind the middle of this rib, and its distal half is furnished with short, irregular branches. The posterior main rib runs at a distance from the dorsal margin of this list equaling about 0.13 the greatest depth of the body and extends to the posterior end of the list; it is fairly weak, slightly irregular, about 0.59 the greatest depth of the body, located about midway between the midline and the antapex, inclined posteroventrally at about 10°–15°, and its distal half has short, irregular branches. The ventral margin of this list is nearly straight anteriorly and gently convex posteriorly; and the ventral and dorsal margins form a posterior angle of about

70°. The portion of the list that is dorsal to the posterior main rib is curled to the right in the middle.

The thecal wall lacks structural differentiation except pores. On the hypotheca there is a close-set row of pores along the girdle. In the transverse furrow there are two close-set rows of pores, one along the posterior cingular list and one along the sagittal suture. Phaeosomes were not observed.

The dimensions of one specimen, the type, were measured.

Dimensions: — Length of body, 15.0 μ. Greatest depth of body, 41.4 μ. Total length, 79 μ.

Comparisons: — The description given above is based on the type specimen.

Histioneis panda is a fairly aberrant and in some respects highly differentiated member of the PULCHRA group. It is readily distinguished from the other members of this group by the large lateral pouches of its posterior cingular list, and by the relatively small size and simple structure of its left sulcal list. It shows similarities to *H. panaria* in the shape of the body and of the posterior cingular list, but these are evidently due to convergences and not to close relationship. It may also be mentioned that it resembles *H. dolon* in having the posterior cingular list furnished with a secondary frill; here again we are concerned with an example of convergence.

Occurrence: — *Histioneis panda* is recorded at only one (4724) of the 127 stations, on the fifth line of the Expedition, in the South Equatorial Drift, from 300–0 fathoms, at a surface temperature of 79°. The frequency is less than 1% (one specimen).

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4724 of the Expedition which thus is the type locality.

6. DOLON GROUP. Only one of the six species of this group, viz., *Histioneis megalocopa*, was not found by us in the Pacific. The remaining species are treated in the following order: — *H. helenae*, *H. milneri*, *H. dolon*, *H. hippoperoides*, and *H. josephinae*.

HISTIONEIS HELENAE Murray and Whitting

Histioneis helenae MURRAY & WHITTING, 1899, p. 333, 335, pl. 33, fig. 2, tab. 1, 6, 8, 9. LEMMERMANN, 1899a, p. 374. KOFOID, 1907a, p. 204.

No drawings or records of variations were made of the specimens of this species found in the material of the Expedition, and so we do not give any diagnosis or description, but refer the reader to Murray and Whitting's (1899) descrip-

tion and figures of the type specimen. With regard to relationships, see *Histioneis dolon*, the section on comparisons.

Occurrence: — *Histioneis helenae* is recorded at five of the 127 stations. There are 0, 0, 0, 2, 2, and 1 stations on the six lines of the Expedition, all of them (4701, 4705, 4730, 4734, 4740) located in the South Equatorial Drift. All records refer to hauls from 300–0 fathoms. The temperature range of these five stations at the surface was 72°–81°; the average was 77.0°. The frequency is less than 1% except at Station 4730 where it is 1%.

Murray and Whitting (1899), who were the first to record this species, found it at five stations in the Atlantic Ocean and the Caribbean Sea, between lat. 31° N. and lat. 14° N. and between long. 35° W. and long. 77° W. The fact that all our record stations are restricted to the South Equatorial Drift is noteworthy.

Histioneis milneri Murray and Whitting

Histioneis milneri Murray & Whitting, 1899, p. 333, 334, pl. 33, fig. 1, tab. 3, 6, 8, 9. Lemmermann, 1899a, p. 374.

No drawings or records of variations were made of the specimens of this species found in the material of the Expedition. This indicates that these specimens agreed well with the type as figured and described by Murray and Whitting (1899). With regard to relationships, see *Histioneis dolon*, the section on comparisons.

Occurrence: — *Histioneis milneri* is recorded at five of the 127 stations. There are 0, 0, 0, 1, 3, and 1 stations on the six lines of the Expedition. Of these five stations, one (4699) is in the Easter Island Eddy; three (4722, 4724, 4730) are in the South Equatorial Drift; and one (4742) is in the South Equatorial Current. All records refer to hauls from 300–0 fathoms. The temperature range of these five stations at the surface was 75°–79°; the average was 77.0°. The frequency is in each case less than 1%.

Murray and Whitting (1899), who were the first to record this species, found it at seven stations in the Atlantic Ocean and the Caribbean Sea, between lat. 35° N. and lat. 10° N., and between long. 29° W. and long. 80° W., in surface waters of 76.0° (62°–84°). With regard to the distribution of this species in the region investigated by the Expedition, the absence of record stations in the coastal currents is the most outstanding feature.

Histioneis dolon Murray and Whitting

Figure 96: 6; 101

Histioneis dolon Murray & Whitting, 1899, p. 333, 335, pl. 33, fig. 5, tab. 6, 8. Lemmermann, 1899a, p. 374. Schröder, 1906b, p. 263. Karsten, 1907, p. 272. Gadeceau, 1909, p. 9, fig. 2. Kofoid & Michener, 1911, p. 296.

Diagnosis: — Body short saddle-shaped, strikingly higher dorsally than ventrally; length: depth, 0.77–0.78: 1. Dorsally the transverse furrow is 0.49–0.56 the depth of body, 10–15 times wider than ventrally, inclined dorsoanteriorly at 1°–10°, and strongly concave. Distance from apex to posterior cingular list 0.08–0.10 the base of this list. Anterior cingular list with long stalk; its height 1.72–2.00 the depth of body; 10–12 times wider distally than proximally, flaring in the distal 0.5, and widely in the distal 0.2. Dorsal height of posterior cingular list 1.40–1.42 the depth of body; frill wide; with secondary frill 0.18–0.33 as high as list, having six to seven simple ribs. Left sulcal list large, tongue-shaped; with large, rounded posterodorsal transverse fin, 1.48–1.64 the depth of body; R_2 almost straight, deflected posteriorly at about 35°; R_3 located midway between R_2 and antapex, almost unbranched; length of list 1.70–1.88 the depth of body. Theca with pores only. Total length, 139–156 μ.

Widely distributed in tropical and subtropical seas.

Description: — This is a large species, short saddle-shaped, strikingly higher dorsally than ventrally. The ratio between the length and the depth of the body is 0.77–0.78: 1. The longitudinal axis is deflected posterodorsally at about 35°–45°.

The epitheca is 0.08–0.17 as deep as the hypotheca, gently convex, highest in or near the center, and tilted dorsoposteriorly at 5°–15°. Dorsally the transverse furrow is 0.49–0.56 the greatest depth of the body, 10–15 times wider than ventrally, strongly concave, and inclined dorsoanteriorly at 1°–10° to the horizontal plane. The distance from the apex to the posterior cingular list is 0.08–0.10 the base of this list. The anterior margin of the hypotheca is strongly concave and subparallel to the outline of the dorsal portion of the transverse furrow. Its ventral, posterior, and dorsal margins are confluent; posteroventrally it is flattened, posterodorsally strongly convex. When seen in dorsoventral view, the body is pear-shaped, broadly rounded posteriorly, narrowly rounded anteriorly, and but slightly longer than wide (Murray and Whitting, 1899, pl. 33, fig. 5b).

The anterior cingular list has a long stalk and is 10–12 times wider distally than proximally; its height is 1.72–2.00 the greatest depth of the body, and its right side is moderately lower than its left, the margin curving abruptly to the shallow ventral notch; distally it has a submarginal rib with a series of 15–20

subequidistant anterior branches on each valve. The posterior cingular list is closed; when seen in dorsoventral view, it has, posteriorly, lateral pouches of moderate size (Murray and Whitting, 1899, pl. 33, fig. 5b); its dorsal height is 1.40–1.42, its ventral height 1.25–1.35 the greatest depth of the body; the frill is dorsally about 0.80–0.90 the dorsal rib, of moderate height in the middle, and has a secondary frill, which is 0.18–0.33 as high as the dorsal rib and has a series of six to seven subequidistant, simple longitudinal ribs on each valve; behind the secondary frill, this list has an irregular, wide-meshed reticulum; its lateral pouches lack structural differentiation.

The left sulcal list is very large, tongue-shaped, and is characterized especially by a large, rounded posterodorsal transverse fin, the diameter of which is 1.48–1.64 the greatest depth of the body. The margin of this list in front of the fission rib is rather strongly convex. The two fission ribs run close to each other, are nearly straight or gently undulating, and have a posterior deflection of about 35°; their length is 1.45–1.61 the greatest depth of the body. The posterior main rib is located about midway between the fission ribs and the antapex, runs about parallel to the fission ribs, is simple or furnished with but a few weak branches, and measures, when fully developed, 1.70–1.80 the greatest depth of the body. In front of the fission ribs, this list has two or three ribs running about parallel to the ventral margin of the list and in most specimens connected by a number of subperpendicular branches; dorsally to these ribs some irregular ribs may also be found. The posterodorsal transverse fin is characterized by very fine concentric striations. The length of the left sulcal list is 1.70–1.88 the greatest depth of the body.

The theca is smooth. The hypotheca has a dense row of pores along the girdle and a fairly great number of scattered pores. In the transverse furrow there is a dense row of pores along the posterior cingular list and along the sagittal suture, and also scattered pores. Phaeosomes have not been observed.

The dimensions of one of our specimens and of the type (Murray and Whitting, 1899, pl. 33, fig. 5) were measured.

Dimensions: — Our specimen: Length of body, 28.9 μ. Greatest depth of body, 37.1 μ. Total length, 139 μ. Type specimen (Murray and Whitting, 1899, pl. 33, fig. 5a): Length of body, 30.0 μ. Greatest depth of body, 38.8 μ. Total length, 156 μ.

Variations: — Judging by the comparatively few specimens recorded as yet, this species appears to be quite constant in shape and structure. The size, too, is fairly constant.

Comparisons: — Our specimens agree so closely with the type as figured by Murray and Whitting (1899, pl. 33, fig. 5a, b) that there can be no doubt as to the correctness of their specific allocation.

This species is certainly very closely related to *Histioneis milneri*, *H. helenae*, *H. hippoperoides*, and *H. megalocopa*. These relationships are suggested by striking similarities in the shape of the body, and in the shape and structure of the cingular and sulcal lists. The body is of short saddle-shape, strikingly higher dorsally than ventrally. The anterior cingular list has, except possibly in *H. megalocopa*, a submarginal rib with a series of subequidistant anterior branches. The posterior cingular list is characterized by a very broad frill, which, except in *H. megalocopa*, has a fairly narrow secondary frill bordered by a cross-rib furnished with a series of subequidistant anterior branches. The left sulcal list is very large, of broad tongue-shape, has a transverse fin posterodorsally, has one or more ribs running parallel to the ventral margin, and its two fission ribs run close to each other and have but a moderate posterior deflection. *H. dolon* differs from *H. milneri* and *H. helenae* in the very large size of the transverse posterodorsal fin of its left sulcal list and in the better-developed lateral pouches of its posterior cingular list. *H. hippoperoides*, which agrees with *H. dolon* in these two characters, differs from this species in its somewhat smaller size, in the narrower opening of its anterior cingular list, and in the better-developed structural differentiation of its left sulcal list. *H. megalocopa* is readily recognized from all these species by having the whole frill of the posterior cingular list furnished with rather fine-meshed reticulation.

Synonymy: — This species was established by Murray and Whitting (1899) under the name of *Histioneis dolon*, a name also used by all the succeeding investigators in this field. Gadeceau (1909) gives reproductions of Murray and Whitting's (1899) figures of the type specimen.

Occurrence: — *Histioneis dolon* is recorded at sixteen of the 127 stations. There are 1, 0, 4, 4, 6, and 1 stations on the six lines of the Expedition. Of these sixteen stations, one (4623) is in the Panamic Area; five (4689, 4691, 4695, 4697, 4699) are in the Easter Island Eddy; and ten (4681, 4685, 4701, 4717, 4724, 4725, 4732, 4734, 4737, 4740) are in the South Equatorial Drift. At one station (4623) the species was found in a surface catch; at one station (4725) in a Salpa from surface waters; at one station (4737) it was taken in a haul from 100–0 fathoms as well as in one from 300–0 fathoms; at three stations (4681, 4701, 4724) in hauls from both 800–0 fathoms and 300–0 fathoms. The remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these sixteen stations at the surface was 68.0°–81.5°; the average was 75.9°. At Stations 4623 and 4725, in the surface catches of which this species was found, the surface temperatures were 79° to 77°, respectively. The frequency is in all cases less than 1%.

Murray and Whitting (1899) found this species at two stations in the Sargasso Sea, in surface waters of 67° and 74°; Karsten (1907) found it in the Indian Ocean, at lat. 7° 43′ N., long. 88° 44′ E. Karsten (1907) does not give any figures, and so his determinations cannot be checked.

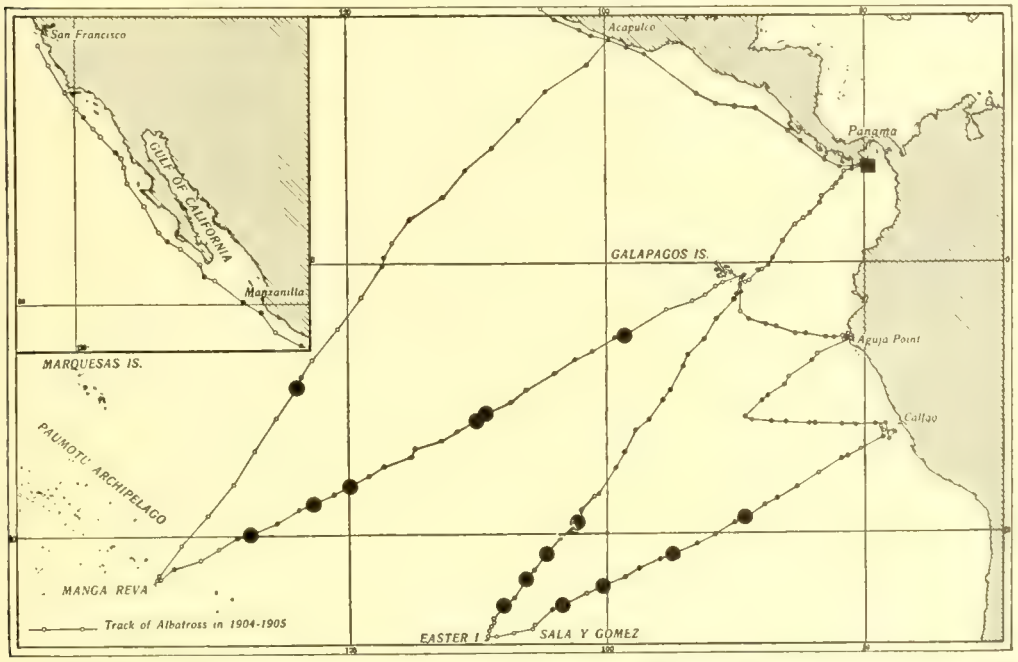

FIGURE 101.— Occurrence of *Histioneis dolon* Murray and Whitting. Large, solid circles indicate records from vertical hauls; squares, records from surface hauls; small, solid circles, stations at which this species was not found; small, open circles, stations from which no plankton catches were examined.

This species is eupelagic and widely distributed but rare in tropical and subtropical seas. The most characteristic features of its occurrence in the eastern Pacific, according to our data, are its rarity in surface waters and the concentration of its record stations in the Easter Island Eddy and in the South Equatorial Drift.

HISTIONEIS HIPPOPEROIDES Kofoid and Michener

Plate 23, fig. 1, 3. Figure 96: 5

Histioneis hippoperoides KOFOID & MICHENER, 1911, p. 296.

Diagnosis: — Body short saddle-shaped, higher dorsally than ventrally; length: depth, 0.77: 1. Dorsally the transverse furrow is 0.37 the depth of body,

five to six times wider than ventrally, inclined dorsoanteriorly 5°–10°, and moderately concave. Distance from apex to posterior cingular list about 0.20 the base of this list. Anterior cingular list with long stalk; its height 1.03 the depth of body; 2.0–2.5 times wider distally than proximally, flaring but little and only in the distal 0.3. Dorsal height of posterior cingular list 0.91 the depth of body; frill wide; with secondary frill 0.15–0.17 as high as list, having 12–17 simple ribs. Left sulcal list rather large, tongue-shaped; with large, rounded posterodorsal transverse fin, 1.0 the depth of body; R_2 almost straight, deflected posteriorly at about 35°; R_3 located midway between R_2 and antapex, with a few perpendicular ventral branches; length of list 1.12 the depth of body. Theca with pores only. Total length, 95 μ.

Eastern tropical Pacific.

Description: — This is a fairly large species, of short saddle-shape, higher dorsally than ventrally. The ratio between the length and the depth of the body is 0.77: 1. The longitudinal axis is deflected posterodorsally at about 40°–45°.

The epitheca is 0.13 as deep as the hypotheca, gently convex, highest in or near the center, and subhorizontal. Dorsally the transverse furrow is 0.37 the depth of the body, five to six times wider than ventrally, moderately concave, and inclined dorsoanteriorly at 5°–10° to the horizontal plane. The distance from the apex to the posterior cingular list is about 0.20 the base of this list. The anterior margin of the hypotheca is strongly concave and inclined dorsoanteriorly at 15°–20° to the horizontal plane. Its ventral, posterior, and dorsal margins are confluent; posteroventrally it is flattened, gently convex; posterodorsally it is strongly and evenly convex. When seen in dorsoventral view, the body is pear-shaped, broadly rounded posteriorly, narrowly rounded anteriorly, and about as long as wide.

The anterior cingular list has a long stalk and is 2.0–2.5 times wider distally than proximally; its height is about 1.03 the greatest depth of the body, and its right side is but slightly, if at all, lower than its left; distally it has a submarginal rib with a series of subequidistant anterior branches; behind this rib some more ribs may be present. The distal flare is subuniform and confined mainly to the distal third. The posterior cingular list is closed; in the type specimen its dorsal margin is irregularly undulating, with a fairly pronounced concavity (possibly an artifact) near the middle; when seen in dorsoventral view, it has, posteriorly, lateral pouches of fairly large size; its dorsal height is about 0.91, its ventral height 0.73 the greatest depth of the body; the frill is dorsally about 0.62 the dorsal rib, somewhat narrower in the middle, and has a secondary frill, which is

about 0.15–0.17 as high as the dorsal rib and has a series of 12–17 simple, subequidistant longitudinal ribs on each valve; behind the secondary frill this list has an irregular, wide-meshed reticulum; its lateral pouches almost lack structural differentiation. The left sulcal list is fairly large, tongue-shaped, and is characterized especially by a large, rounded posterodorsal transverse fin, the diameter of which is about 1.0 the greatest depth of the body. The ventral margin of this list is rather strongly and almost evenly convex. The two fission ribs run close to each other, are nearly straight, and have a posterior deflection of about 35°; their length is about 0.95 the greatest depth of the body. The posterior main rib is located about midway between the fission ribs and the antapex, runs about parallel to the fission ribs, is furnished with a few almost perpendicular branches, and is but slightly longer than the fission ribs. In front of the fission ribs, this list has three ribs running about parallel to the ventral margin of the list and connected by a great number of subperpendicular branches, thus forming a regular reticulum of rectangular meshes; dorsally to these ribs an irregular wide-meshed reticulum is developed. Behind the fission ribs this list has an irregular wide-meshed reticulum with a tendency to elongation in the periphery; and the posterodorsal transverse fin has a few incomplete, concentric ribs. The length of this rib is about 1.12 the greatest depth of the body.

The theca is smooth. The hypotheca has a close-set row of pores along the girdle and a fairly great number of scattered pores. In the transverse furrow there is a close-set row of pores along the posterior cingular list and along the sagittal suture, and also scattered pores. Phaeosomes have not been observed.

The dimensions of the type specimen only were measured.

Dimensions: — Length of body, 29.2 μ. Greatest depth of body, 38.2 μ. Total length, 95 μ.

Comparisons: — Our description and figures are based on the type material.

The species is very closely related to *Histioneis milneri, H. helenae, H. dolon,* and *H. megalocopa*. For a discussion of these relationships and for the distinguishing characteristics of these species, see *H. dolon,* the section on comparisons.

Occurrence: — *Histioneis hippoperoides* is recorded at only one of the 127 stations. This station (4590) is on the first line of the Expedition and in the Mexican Current. Depth, 300–0 fathoms; surface temperature, 82°–83°. The frequency was less than 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid and Michener (1911) from Station 4590 of the Expedition, which thus is the type locality.

Histioneis josephinae Kofoid

Plate 22, fig. 1–3; Plate 23, fig. 4. Figure 96: 7

Histioneis josephinae Kofoid, 1907a, p. 204, pl. 15, fig. 91.

Diagnosis: — Body of short saddle-shape, strongly curved, strikingly higher dorsally than ventrally; length: depth, 0.63–0.64: 1. Dorsally the transverse furrow is 0.39 the depth of body, five to six times wider than ventrally, inclined dorsoanteriorly at 25°–30°, and strikingly concave. Distance from apex to posterior cingular list about 0.06 the base of this list. Anterior cingular list with long stalk, 0.5 its total length; its height 1.45–1.50 the depth of body, flaring distally asymmetrically to 50°. Dorsal height of posterior cingular list 0.96–1.00 the depth of body; frill about half as high as this list, with irregular reticulation. Left sulcal list very large, broadly rounded posteriorly; with long, narrowly rounded posterodorsal projection, a pair of large transverse fins from R_3, a large left fin from R_2, and one along ventral margin in front of R_2; posterodorsal projection and accessory fins bear coral-like thickenings distally near margin; R_2 almost straight, deflected posteriorly at 45°. Theca with pores only. Body pink, fins pale blue. Total length 115–135 μ.

Eastern tropical Pacific.

Description: — This is a large and very handsome species, with body of short saddle-shape, strongly concave anteriorly, strikingly higher dorsally than ventrally. The ratio between the length and the depth of the body is 0.63–0.64: 1. The longitudinal axis is deflected posterodorsally at 50°–60°.

The epitheca is about 0.13 as deep as the hypotheca, gently convex or concave, and subhorizontal. Dorsally the transverse furrow is about 0.39 the greatest depth of the body, five to six times wider than ventrally, strikingly concave, and inclined dorsoanteriorly at 20°–30° to the horizontal plane. The distance from the apex to the posterior cingular list is about 0.06 the base of this list. The anterior margin of the hypotheca is strongly concave and subparallel to the outline of the dorsal portion of the transverse furrow. Its ventral, posterior, and dorsal margins are evenly convex and confluent; the convexity is most pronounced posterodorsally. When seen in dorsoventral view, the body is broadly ovoidal, broadly rounded posteriorly, narrowly rounded anteriorly, and about as long as wide.

The anterior cingular list has a long stalk and is about seven times wider distally than proximally; its height is 1.45–1.50 the greatest depth of the body, its right margin is distinctly lower than its left, and it is notched ventrally; distally it

has a submarginal rib with a number of rather irregular, anastomosing anterior branches; behind this rib some more ribs may be present. The posterior cingular list was open in the type specimen but is probably closed when typically developed (compare *Histioneis carinata*); its dorsal margin may be gently concave or of about the same irregular shape as in *H. hippoperoides;* no lateral pouches are present, although there is some outward bulging of the left side; its dorsal height is 0.96–1.00, its ventral height 0.78–1.10 the greatest depth of the body; the frill is about half as wide as this list and has typically a secondary frill, which is about 0.15 as high as the dorsal rib and has a number of subequidistant longitudinal ribs; between the ribs of the primary and secondary frills an irregular, wide-meshed reticulum may be present; behind the primary frill this list has less structural differentiation.

The right sulcal list continues beyond the margin of the theca to a distance slightly greater than from that point to the flagellar pore; it is very narrow at this pore, lanceolate posteriorly, and has a rib along the dorsal margin. The left sulcal list is very large, broadly rounded posteriorly, and has a narrowly rounded dorsal projection, the length of which is approximately 0.6 the greatest depth of the body. The two fission ribs run close to each other, are simple and nearly straight, and have a posterior deflection of about 45°; their length is subequal to the greatest depth of the body. The posterior main rib arises at a point somewhat dorsally to the point midway between the fission ribs and the antapex, is simple, runs about parallel to the fission ribs, and ends near the middle of the posterior portion of this list; its length is about 0.66 the greatest depth of the body. The width of this list at the posterior main rib is about 1.64 the greatest depth of the body. Arising from the originally free ventral edge of this list, there is in front of the fission rib a subtrapeziform accessory fin, the basal length and the greatest width of which are 1.06 and 0.46 the greatest depth of the body, respectively; the greatest width is located near the anterior end; near the posterior end this accessory fin is only 0.23 the greatest depth of the body (compare the accessory left sulcal list in *Amphisolenia laticincta* and *A. curvata*). On the left side of this list, arising along the entire length of the fission ribs, there is a large, squarish accessory fin, the anterior and posterior margins of which are nearly straight, while the ventral margin is sigmoid; the anterior and posterior widths of this accessory fin are 0.95 and 1.18 the greatest depth of the body, respectively; and its distal extension is about 1.36 the greatest depth of the body.

Finally, a pair of large, accessory fins, resembling a pair of butterfly wings, originate from the posterior main rib of this list, one fin on either side of the list.

The length and the anterior width of these fins are 0.83–0.88 and 0.70 the greatest depth of the body; they are widest anteriorly and gradually decrease in width posteriorly; their anterior margins are strongly curved, their lateral margins are gently sigmoid. In front of the fission rib this list has one or a few simple ribs. Along the dorsal and distal margins of the posterodorsal projection of this list, there is a chain of coral-like thickenings; and a few small irregular thickenings are also found on the posterior margin of this list. The accessory fin of the ventral margin of this list has a bifurcate rib, originating near the middle of the base of the fin; its two branches, which extend to the anterior and posterior angles of the fin, are furnished with coral-like thickenings. The accessory fin of the fission rib is bordered anteriorly by a rib, the distal end of which has coral-like thickenings; from the base of the thickened end of this rib an exceedingly fine rib runs about parallel to the ventral margin of this fin, ending at the tip of the fission rib; thus this fin is divided into two segments, a large basal one, which lacks structural differentiation, and an excessively thin and hyaline marginal one, the average width of which is about 0.26 the greatest depth of the body, and which has four ribs posteriorly, the two anterior ones with coral-like thickenings, the two posterior ones simple, very small and weak. Each of the accessory fins of the posterior main rib has a chain of coral-like thickenings along its anterior margin. The right one of these fins is divided by a very fine, longitudinal rib into two segments, the outer one of which is somewhat larger than the inner and excessively thin and hyaline; the outer segment has four ribs posteriorly, three of which have coral-like thickenings.

The thecal wall is smooth. The hypotheca has a dense row of pores along the girdle and a fairly great number of scattered pores. In the transverse furrow there is a dense row of pores along the posterior cingular list and along the sagittal suture, and also scattered pores. Phaeosomes were not observed. The body is pink, the anterior cingular list canary yellow, the posterior cingular list pale pearl-gray, the sulcal lists pale yellow (Plate 23, fig. 4), and the coral-like thickenings have pearl-gray sheen.

The dimensions of two specimens were measured.

Dimensions:— Length of body, 22.6–23.5 μ (type, 23.5 μ). Greatest depth of body, 35.6–36.7 μ (type, 36.7 μ). Total length, 112–135 μ (type, 135 μ).

Comparisons: — Our figures and description are based on the type material.

This species, which is characterized by the most striking development of the organs of flotation among the dinoflagellates, occupies apparently a fairly isolated position within its genus. The shape of the body, the development of transverse

fins from the posterior main rib of the left sulcal list, the position of this rib, and the shape and direction of the fission rib of this list seem to indicate relationships to *Histioneis dolon, H. milneri, H. helenae, H. hippoperoides,* and *H. megalocopa;* but in most other respects *H. josephinae* has such a unique structure that even these relationships must be considered as questionable. If *H. josephinae* is not closely related to the mentioned species, then we are confronted by a new example of the independent appearance in highly elaborated forms of characteristics that were inherent in but not expressed by the common ancestors.

Occurrence: — *Histioneis josephinae* is recorded at four of the 127 stations. Of these four stations, three (4695, 4697, 4699) are on the fourth line of the Expedition and in the Easter Island Eddy; one (4739) is on the fifth line and in the South Equatorial Drift. All records refer to hauls from 300–0 fathoms. The surface temperature was 75.8° (74°–79°); the frequency in all cases was less than 1%.

The species has been found only in the material of the Expedition. It was first recorded by Kofoid (1907a) from Station 4699 of the Expedition, which thus is the type locality. The restriction of all the record stations to the Easter Island Eddy and the South Equatorial Drift is noteworthy.

4. CITHARISTIDAE, fam. nov.

Diagnosis: — Body reversed C-shaped in right lateral view. Transverse furrow narrow except dorsally where it forms the large phaeosome chamber, occupying the concavity of the C. Posterior cingular list narrow except dorsally where it encloses the phaeosome chamber. Length of body, 38.2–66.6 μ.

Only one genus, Citharistes, which is marine, eupelagic, and circumequatorial.

Citharistes Stein

Citharistes Stein, 1883, p. 24. Bütschli, 1885, p. 944, 1010. Schütt, 1896, p. 29. Delage & Hérouard, 1896, p. 385.
Cytharistes Hensen, 1911, p. 162 (*lapsus pennae*).

Diagnosis: — Body reversed C-shaped in right lateral view; length: depth, 1.11–1.60: 1. Epitheca low, disk-like, 0.25–0.37 as deep as hypotheca. Transverse furrow narrow, 0.10–0.18 the greatest depth of body, except dorsally where it forms the large phaeosome chamber, occupying the concavity of the C. Anterior cingular list funnel-shaped; its dorsal height 0.17–0.43 the greatest depth of body; with 5–13 simple, complete ribs on each valve. Posterior cingular list of

about the same anterior inclination as and somewhat narrower than the anterior, except dorsally where it encloses the phaeosome chamber; with a pair of dorsal ribs, one on each side of sagittal suture arising at tip of posterior shank of the C-shaped body, and 0.70–0.96 the greatest depth of body; besides these ribs, this list may have 10–11 ribs of the same kind as those of the anterior list. Right sulcal list small, ending somewhat in front of or behind fission rib of left sulcal list. Left sulcal list of moderate size, ending posteroventrally, with a maximum width 0.14–0.38 the greatest depth of body, rounded posteriorly, and with a varying number of radial ribs. With phaeosomes in the phaeosome chamber.

Type.— *Citharistes regius* Stein.

Distribution: — Citharistes is marine, eupelagic, of circumequatorial distribution, and restricted to tropical, subtropical, and warm-temperate seas. At the present writing, it has been found in the Atlantic, between the equator and lat. 40° N., in the Caribbean Sea, in the Mediterranean, and in the Pacific, at lat. 7° N., long. 133° E. Our knowledge of the distribution of the genus as a whole, as well as that of the individual species is very fragmentary.

The vertical distribution of the genus is unknown. Most of the published records refer to surface hauls, and there are no records based on catches made with closing nets. The species are very rare.

Representatives of Citharistes were found at fifteen (11.8%) out of the 127 stations of the Expedition from which dinoflagellates were recorded. One (4590) of these fifteen stations is in the Mexican Current; one (4635) is in the Panamic Area; three (4695, 4697, 4699) are in the Easter Island Eddy; nine (4680, 4681, 4701, 4709, 4712, 4717, 4720, 4737, 4741) are in the South Equatorial Drift; one (4541) is in the Equatorial Counter Current. At two (4635, 4541) of these fifteen stations the genus was taken in surface hauls; at five stations (4680, 4709, 4712, 4720, 4741) it was found in Salpa taken in surface waters. The remaining eight records refer to hauls from 300–0 fathoms (Figure 103).

These data show that the genus was not taken by the Expedition in the California and Peruvian Currents, both of which are of cold origin, in the Galapagos Eddy, which is under the direct influence of the Peruvian Current, nor in the South and the North Equatorial Currents. Most (nine out of fifteen) of the record stations are in the South Equatorial Drift. The genus evidently is stenothermal and stenohaline, and limited to waters of relatively high temperatures and salinities.

Historical Discussion: — Citharistes, which was established by Stein (1883), comprises two known species, viz., *C. regius* Stein (1883) and *C. apsteini* Schütt

(1895), for neither of which a specific diagnosis and description have as yet been given. Of the three generic diagnoses published by Bütschli (1885, p. 1010), Delage and Hérouard (1896, p. 385), and Schütt (1896, p. 29), the one by Schütt is the most nearly complete and critical. Short discussions of the genus are found in Stein (1883, p. 24) and Bütschli (1885, p. 944).

Besides Stein (1883) the following investigators have contributed data on the distribution of this genus: — Cleve (1901c), Entz (1907, 1909), Gräf (1909), Hensen (1911), Lemmermann (1899a, 1901a), Murray and Whitting (1899), and Schröder (1900a). Of these only Murray and Whitting (1899) give original figures. References to this genus or minor contributions are found in Balbiani (1884c), Bergh (1884), Calkins (1902), Hensen (1891), and Lang (1901). Hensen (1911) wrote Cytharistes instead of Citharistes.

Citharistes regius Stein

Figure 102: 6; 103

Citharistes regius Stein, 1883, pl. 22, fig. 1–4. Bütschli, 1885, pl. 55, fig. 5. Lemmermann, 1899a, p. 374. Murray & Whitting, 1899, p. 336, tab. 6. Entz, 1907, p. 11; 1909, p. 246.
Cytharistes regius Hensen, 1911, tab. 15.
Citharistes sp. Hensen, 1891, p. 68, tab. 2.

Diagnosis: — Body reversed C-shaped in right lateral view, deepest somewhat behind the middle; length: depth, 1.34–1.60: 1. Its transection subuniform throughout anterior half of curvature, 0.28–0.36 the depth of body, and strikingly greater posteriorly than anteriorly; greatest height of posterior shank, 0.59–0.74 the depth of body. Distance between tips of C, 0.65–0.70 the depth of body. Postmargin strongly and evenly convex, often nearly semicircular. Height of anterior cingular list 0.27–0.43 the depth of body. Dorsal ribs of phaeosome chamber gently sigmoid, concave or subangular anteriorly; their length 0.77–0.96 the depth of body. Left sulcal list ends at posteroventral corner of body, widest near posterior end; its greatest width 0.38 the depth of body; its margin gently concave or nearly straight anteriorly, strongly convex posteriorly. Length, 38.2 μ.

Tropical and subtropical seas.

Description: — This is a fairly small species, the body of which is reversed C-shaped in right lateral view and deepest somewhat behind the middle. The ratio between the length and the depth of the body is 1.34–1.60: 1. The longitudinal axis is perpendicular. The transection is subuniform throughout the anterior half of the curvature of the C, 0.28–0.36 the greatest depth of the body, and strikingly greater posteriorly than anteriorly; the greatest height of the posterior shank is 0.59–0.74 the greatest depth of the body. The anterior tip of the C is

well rounded, the posterior is well rounded or subrectangular. The distance between these tips is 0.65–0.70 the greatest depth of the body. The epitheca is 0.25–0.28 as deep as the hypotheca, gently convex and highest in or near the center, or flattened. The ventral margin of the body is gently and evenly convex (Figure 102: 6) or gently sigmoid (Stein, 1883, pl. 22, fig. 1–4), and confluent with the postmargin. The postmargin is subsemicircular or slightly flattened. The very strongly concave dorsal margin is subsemicircular.

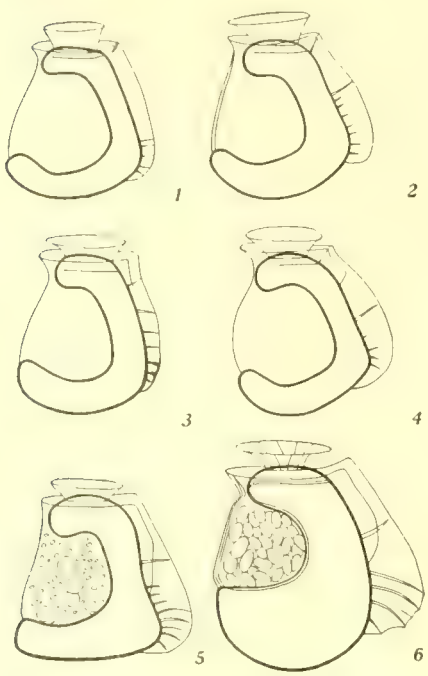

FIGURE 102.— Citharistes, right lateral view. 1–5, *C. apsteini* Schütt. × 340. 6, *C. regius* Stein. × 700. 1, from Station 4681 (300–0 fathoms); 2, from Station 4701 (300–0 fathoms); 3, from Station 4695 (300–0 fathoms); 4, from Station 4697 (300–0 fathoms); 5, from Station 4720 (Salpa); 6, from Station 4717 (300–0 fathoms).

The anterior cingular list is funnel-shaped and sometimes strikingly flaring distally; its flares equally extended dorsally and ventrally with concave sides and horizontal base and top; the dorsal height is 0.27–0.43 the greatest depth of the body; and it has on each valve five to ten simple, complete subequidistant radial ribs. The posterior cingular list is somewhat narrower than the anterior and appears to lack structural differentiation. The distance from the apex to the base of this list is 0.07–0.11 the length of the body. The portion of this list that includes the phaeosome chamber may have a weak reticulation posteriorly; and its two dorsal ribs are 0.77–0.96 the greatest depth of the body and gently sigmoid, concave, or subangular anteriorly. The right sulcal list ends somewhat in front of or behind the fission rib, is of subuniform width anteriorly and decreases gradually in width posteriorly; its anterior width is about 0.13 the greatest depth of the body. The left sulcal list ends at the posteroventral corner of the body and is widest near its posterior end; its greatest width is about 0.38 the greatest depth of the body; its margin is gently concave or convex, or nearly straight anteriorly, and rather strongly convex posteriorly. Its fission rib is located near the middle and is subhorizontal or slightly deflected anteriorly. Behind this rib the list has three to six ribs, most of which are simple and complete, but some of which may be incomplete or branched.

The thecal wall of the hypotheca is reticulate (and probably porulate); about 9–11 meshes border the girdle posteriorly. In the phaeosome chamber there are numerous ovoidal phaeosomes of medium size.

The dimensions of one of our specimens and of the specimens figured by Stein (1883, pl. 22, fig. 1–4) were measured.

Dimensions: — One of our specimens: Length of body, 38.2 μ. Greatest depth of body, 28.6 μ. The size of the specimens figured by Stein (1883) is unknown. According to Stein's (1883) information about the magnifications of his figures given in an introductory remark to the explanations of the plates, they had a length of body somewhere between 50.5 μ and 84.5 μ.

Variations: — Judging by the few specimens figured up to the present time, this species appears to be decidedly constant.

Comparisons: — Disregarding a possible difference in size (see the paragraph on dimensions), our specimens differ from those figured by Stein (1883, pl. 22, fig. 1–4) mainly in two respects: — (*1*) the anterior cingular list is somewhat narrower and (*2*) the dorsal ribs of the phaeosome chamber join the posterior cingular list. Stein makes these ribs end on the dorsal side of the body at a short distance behind the posterior cingular list, except in his Plate 22, figure 4, in which they can be traced clear up to the posterior margin of this list. The latter of these two differences undoubtedly is apparent only, and due to Stein's overlooking the anterior portions of the above-mentioned ribs. The unity of this species may be considered as certain.

Citharistes regius differs strikingly from *C. apsteini* in having the posterior portion of the horseshoe-shaped body decidedly thicker than the anterior.

Synonymy: — This species was established by Stein (1883), under the name of *Citharistes regius*, and this name was used also by the succeeding investigators who have treated this form. Of the three specimens figured by Stein (1883, pl. 22, fig. 1–4) we regard the one represented by his Plate 22, figure 1, as the type. Bütschli (1885, pl. 55, fig. 5) gives a reproduction of this last figure.

Occurrence: — *Citharistes regius* is recorded at five of the 127 stations. There are 0, 0, 1, 2, 1, and 1 stations on the six lines of the Expedition, and all of them (4680, 4709, 4712, 4717, 4741) are located in the South Equatorial Drift. Eight specimens were found, one of which was taken in a haul from 300–0 fathoms at Station 4717, the remaining ones occurring in Salpa taken in surface waters. The surface temperatures of these five stations ranged from 68° to 80°; the average was 73.8°.

Stein (1883) recorded this species "aus dem Atlantischen Meer und der

Südsee." Murray and Whitting (1899) found it at one station in the Atlantic Ocean, viz., at lat. 31° N., long. 35° 30′ W.; temperature, 70°. Hensen (1911) recorded it from five stations in the Atlantic Ocean, viz., in the Sargasso Sea and the Canary Current and off the coast of Brazil. It was taken by Entz (1907, 1909) in the Gulf of Naples.

The species is eupelagic and widely distributed but very rare in tropical, subtropical, and warm-temperate seas. The restriction of all our record stations to the South Equatorial Drift is noteworthy.

Citharistes apsteini Schütt

Figure 102: 1–5; 103

Citharistes apsteinii Schütt, 1895, pl. 5, fig. 24; 1896, p. 30, fig. 43. Lemmermann, 1899a, p. 374; 1901a, p. 377. Murray & Whitting, 1899, p. 336, pl. 31, fig. 3, tab. 3, 6, 8, 9. Cleve, 1901c, p. 236.
Citharistes apstein Gräf, 1909, p. 194.
Citharistes (sp.) Delage & Hérouard, 1896, p. 385, fig. 675.

Diagnosis: — Body reversed C-shaped in right lateral view, deepest near posterior end; length: depth, 1.11–1.27: 1. Its transection either subuniform throughout the entire curvature, 0.19–0.30 the depth of body, or it forms a broadly rounded to subangular posteroventral protuberance, in which case its transection at this place is greater than elsewhere, 0.44–0.48 the depth of body. Distance between tips of C is 0.50–0.66 the depth of body. Postmargin well and evenly convex, gently convex, or gently sigmoid. Height of anterior cingular list 0.17–0.27 the depth of body. Dorsal ribs of phaeosome chamber gently sigmoid, concave anteriorly, their length 0.70–0.92 the depth of body. Left sulcal list ends at or somewhat behind posteroventral corner of body; of subuniform width throughout and rounded posteriorly, or gently decreasing in width posteriorly; its greatest width 0.14–0.30 the depth of body. Length, 59.0–66.6 μ.

Tropical and subtropical seas.

Description: — This is a medium-sized species, the body of which is reversed C-shaped in right lateral view and deepest near the posterior end. The ratio between the length and the depth of the body is 1.15 (1.11–1.27): 1. The longitudinal axis is subperpendicular. The transection of the C is either subuniform throughout the entire curvature, 0.23 (0.19–0.30) the greatest depth of the body, or there is a broadly rounded to subangular posteroventral protuberance, in which case the transection at this place is more or less strikingly greater than elsewhere, viz., 0.44–0.48 the greatest depth of the body. The tips of the C are well rounded, and the distance between them is 0.60 (0.50–0.66) the greatest depth of the body. The epitheca is 0.30 (0.25–0.37) as deep as the hypotheca, gently convex, and

highest in or near the center, or flattened. The ventral margin of the body is gently and evenly convex (Figure 102: 3), nearly straight (Figure 102: 1), or gently sigmoid (Figure 102: 5); and it either is confluent with the postmargin, or these margins form together a more or less pronounced, usually well-rounded corner. The postmargin is either evenly and rather strongly convex, or gently convex; or again, it may be gently sigmoid, concave in the middle. The very strongly concave dorsal margin usually is subparallel to the anterior, ventral, and posterior margins; exceptions are the specimens with a posteroventral protuberance. Seen in dorsoventral view (Murray and Whitting, 1899, pl. 31, fig. 3b) the body has straight, parallel sides, and is strongly convex posteriorly; the ratio between the length and the width is 3.2: 1.

The anterior cingular list is funnel-shaped, sometimes strikingly flaring distally; it flares with somewhat greater dorsal than ventral extension, with straight ventral and more or less dorsal sides and nearly horizontal flat top; its dorsal height is 0.23 (0.17–0.27) the greatest depth of the body; and it has on each valve 7–13 simple, complete, subequidistant radial ribs. The posterior cingular list is usually somewhat narrower than the anterior and has on each valve about 10–11 ribs of the same kind as the anterior list. The distance from the apex to the base of the posterior cingular list is 0.07 (0.05–0.11) the length of the body. The portion of this list that includes the phaeosome chamber is reticulated anteriorly and may have an irregular and incomplete reticulation posteriorly (Schütt, 1895, pl. 5, fig. 24: 2); its dorsal ribs are 0.83 (0.70–0.92) the greatest depth of the body and gently sigmoid, being concave anteriorly and convex posteriorly. The right sulcal list ends somewhat behind the fission rib and decreases gradually in width posteriorly; its anterior width is somewhat less than in the left sulcal list, and it may be reticulated. The left sulcal list ends at or somewhat behind the posteroventral corner of the body; and it either is of subuniform width throughout and rounded posteriorly, or it decreases gently in width posteriorly; its greatest width equals 0.20 (0.14–0.30) the greatest depth of the body. This list has a varying number (about 5–12) of ribs, most of which are in the posterior half of the list; some of these ribs are complete, others incomplete; some of them are simple, others are branched and may anastomose. The fission rib, which is near the middle of the list, is subhorizontal or somewhat inclined anteriorly.

The thecal wall of the hypotheca, outside the phaeosome chamber, is porulate and reticulated; the meshes are subuniform, of medium size, 9–11 of them border the girdle posteriorly, and each of them has a pore in the center. In the phaeosome chamber we find a varying number of large, spheroidal, and in some

cases also small, ellipsoidal phaeosomes (Schütt, 1895, pl. 5, fig. 24: 1, 2. Figure 102: 5).

The dimensions of five of our specimens and of the specimens figured by Schütt (1895, pl. 5, fig. 24: 1, 2) and Murray and Whitting (1899, pl. 31, fig. 3) were measured.

Dimensions: — Our specimens: Length of body, 59.2–63.5 μ (average, 61.6 μ). Greatest depth of body, 50.4–57.0 μ (average, 53.5 μ). The specimens figured by Schütt (1895, pl. 5, fig. 24: 1, 2) were 59.0–62.9 μ long (type, 59.0 μ) and 50.5–55.2 μ deep (type, 50.5 μ). The specimen represented by Murray and Whitting (1899, pl. 31, fig. 3a) was 66.6 μ long and 52.3 μ deep.

Variations: — This species is fairly variable in the shape of the body and in the structure and relative size of the left sulcal list. Sometimes the body is of subuniform dimensions throughout, sometimes it is comparatively deep posteroventrally, forming at this place a broadly rounded to subangular protuberance. The postmargin may be evenly and fairly strongly convex (Schütt, 1895, pl. 5, fig. 24: 1), gently convex (Figure 102: 5), or sigmoid, concave in the middle (Schütt, 1895, pl. 5, fig. 24: 2). The left sulcal list sometimes is rather wide posteriorly, and its ribs vary in number, shape, and position.

Comparisons: — The two specimens figured by Schütt (1895, pl. 5, fig. 24: 1, 2) as *Citharistes apsteinii* are quite different, and their specific unity may be questionable. The one represented by his figure 21: 1, the type, has the body in left lateral view shaped like a regular and evenly curved C, subuniform in dimensions throughout; and its left sulcal list is relatively narrow posteriorly. In the other specimen (his fig. 24: 2) the body is relatively deep posteroventrally, forming at this place a broadly rounded protuberance; and its postmargin is gently sigmoid, being concave in the middle; moreover, the left sulcal list is rather wide posteriorly. Since our data are not sufficient for a definite solution of this question, we accept tentatively Schütt's (1895) decision and thus regard these two specimens as specifically identical. The specimen figured by Murray and Whitting (1899, pl. 31, fig. 3a) is in some characteristics, *e.g.*, in the shape of the body, intermediate between the two specimens represented by Schütt (1895). Most of our specimens (Figure 102: 1–3) agree fairly well with the type, except in the fact that their bodies are somewhat more slender. One specimen (Figure 102: 5) shows a striking resemblance to the one figured by Murray and Whitting (1899), and one (Figure 102: 4) is in certain respects intermediate between the last specimen and our typical representatives of this species.

This species is readily distinguished from *Citharistes regius* by having the

posterior portion of the horseshoe-shaped body of about the same height as the anterior.

Synonymy: — This species was established under the name of *Citharistes apsteinii* by Schütt (1895), who figured two specimens, of which the one represented by his Plate 5, figure 24: 1, should be regarded as the type. This specific name was used also by the succeeding investigators in this field. Delage and Hérouard (1896, fig. 675) and Schütt (1896, fig. 43) give somewhat modified reproductions of Schütt's (1895) Plate 5, figure 24: 2.

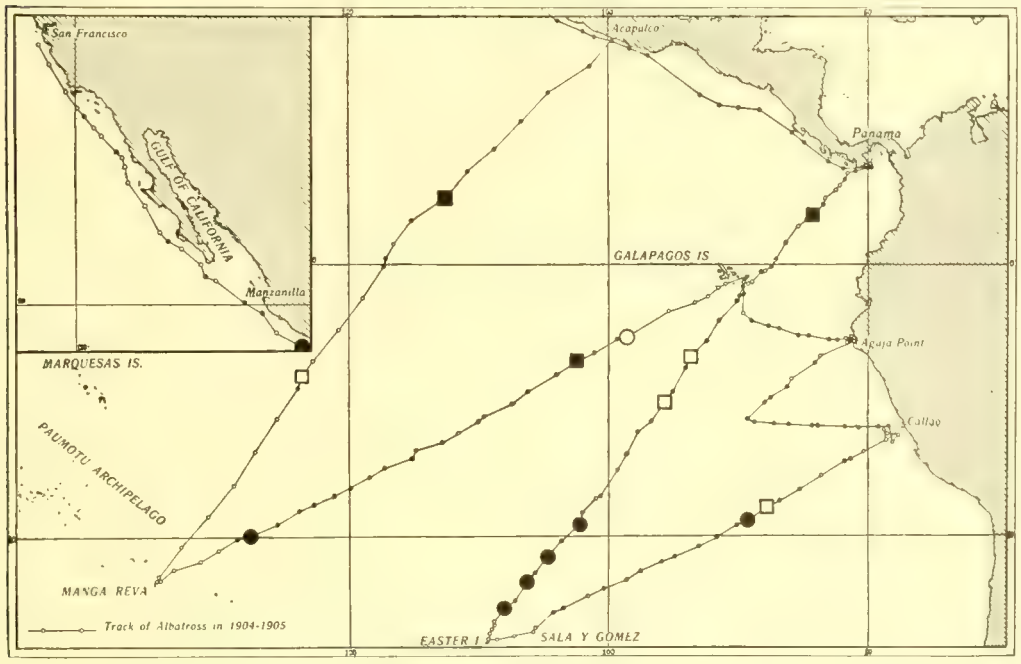

FIGURE 103.— Occurrence of *Citharistes apsteini* Schütt and of *C. regius* Stein. Large, solid circles indicate records of *C. apsteini* from vertical hauls; solid squares, records of *C. apsteini* from surface hauls; large open circles, records of *C. regius* from vertical hauls; open squares, records of *C. regius* from surface hauls; small, solid circles, stations at which these species were not found; small, open circles, stations from which no plankton catches were examined.

Occurrence: — *Citharistes apsteini* is recorded at ten of the 127 stations. There are 1, 1, 1, 4, 2, and 1 stations on the six lines of the Expedition. Of these ten stations, one (4590) is in the Mexican Current; one (4635) is in the Panamic Area; three (4695, 4697, 4699) are in the Easter Island Eddy; four (4681, 4701, 4720, 4737) are in the South Equatorial Drift; and one (4541) is in the Equatorial Counter Current. At two stations (4635, 4541) the species was taken in surface waters only; at one station (4720), in a Salpa from surface waters; all the remaining records refer to hauls from 300–0 fathoms only.

The temperature range of these ten stations at the surface was 68°–83°; the average was 76.4°.

The frequency is in all the cases less than 1%.

Schütt (1895) did not give any information as to the localities of his specimens; however, his material probably was taken either at Naples or in the tropical or the subtropical regions of the Atlantic. Murray and Whitting (1899) found this species at fourteen stations in the Atlantic Ocean and the Caribbean Sea, between lat. 39° N. and lat. 8° N., and between long. 39° W. and long. 80° W., in surface waters of 60°–84°. Cleve (1901c) recorded it from the Atlantic Ocean and the Caribbean Sea, between lat. 29° N. and lat. 10° N., and between long. 20° W. and long. 80° W.; temperature, 73.1° (70.0°–81.9°), thirteen observations; salinity, 36.63, one observation. Gräf (1909) found it at one station in the Pacific Ocean, at lat. 7° 36′ N., long. 133° 12′ E.; temperature, 82.4°; salinity, 34.11.

The species is eupelagic and widely distributed but rare in tropical and subtropical seas. With regard to its distribution in the Eastern Pacific, according to available data, its absence from the Peruvian Current is noteworthy.

III. Distribution of Dinophysoidae at the Stations of the Expedition

The following is a record of the various genera and species of Dinophysoidae noted by us as the result of the examinations, often repeated, of the plankton catches at the various stations of the Expedition. The stations are listed in the numerical order of their record numbers. Their distribution on the six lines of the Expedition is marked off in the list by the insertion of middle headings such as "San Francisco-Panama line" followed by the inclusive station numbers.

With each station number we have given the appropriate data including the temperature at the surface in degrees Fahrenheit. Fuller data will be found in the record of stations in Alexander Agassiz's (1906) report of the Expedition.

The records of occurrence of species at the stations are recorded according to the catch under "Surface" and "300–0 fathoms to the surface," etc. At nearly all stations we have collections made with both No. 12 and No. 20 silk nets. The records of species in the two collections have been combined in a single list. The differences between the two catches lie mainly in the greater proportional loss of the smaller species in the No. 12 net with the coarser mesh. This, together with the fact that the No. 20 catches were more thoroughly examined than those from the No. 12 nets, has made the lists of species from the former somewhat the longer. Since the No. 20 collection generally contained all of the species found in the No. 12 and in larger numbers, there is no change resulting from this combination of the records, except that in a few instances in the No. 12 of additional species, or of larger numbers of individuals of species common to both collections, the sum of the percentages of all species of Dinoflagellates is slightly in excess of 100. This, however, does not appear in the tables since these present only the Dinophysoidae.

There were no Dinophysoidae detected in ten plankton collections from the surface and in five Salpa from surface catches, taken from fifteen different stations as follows: —

Collections of the Expedition in which no Dinophysoidae were found

Station Number	Nature of collection	Surface temperature	Time of day	Contents
4652	surface	66°	8 P.M.	No Dinoflagellata
4655	surface	65°	8 P.M.	No Dinophysoidae
4661	surface	69°	8 P.M.	No Dinophysoidae

Station Number	Nature of collection	Surface temperature	Time of day	Contents
4663	surface	69°	8 P.M.	No Dinophysoidae
4665	surface	67°	8 P.M.	No Dinophysoidae
4667	Salpa	68.5°	8 P.M.	No Dinophysoidae
4671	surface	66°	8 P.M.	No Dinophysoidae
4673	surface	66°	8 P.M.	No Dinophysoidae
4677	surface	68°	8 P.M.	No Dinophysoidae
4683	Salpa	70°	8 A.M.	No Dinophysoidae
4704	Salpa	73°	8 P.M.	No Dinophysoidae
4705	Salpa	72°	8 P.M.	No Dinophysoidae
4706	surface	72°	8 P.M.	No Dinophysoidae
4710	surface	74°	8 P.M.	No Dinophysoidae
4735	Salpa	81°	8 P.M.	No Dinophysoidae

At one of the stations, 4652, no Dinoflagellata of any sort were detected in the surface collection. All of these collections devoid of Dinophysoidae were from the surface and, with the exception of the Salpa from Station 4683 taken at 8 A.M., were taken at 8 P.M. These stations were all within the Peruvian Current or its westward extension, with the sole exception of the last one. They also significantly were made in the waters of lower temperatures, only five being above 70°. These facts reënforce the relations of the Dinophysoidae to the typical tropical environment and to subsurface and deeper waters. The absence of all Dinophysoidae from fourteen of twenty-nine surface collections in the Peruvian Current and its immediate sphere of influence but not the surface collections elsewhere and not from the subsurface collections at these same fourteen stations, is suggestive of the interaction of other factors with temperature in the oceanic distribution of this group.

Distribution by Stations

All records of temperature refer to the surface. P = frequency of less than 1%. All Salpa taken at the surface.

4571

Lat. 33° 40′ N., long. 119° 35′ W. October 7, 1904. Temperature, 71°.

Surface: — *Dinophysis caudata*, 72%.

300 fathoms to surface: — *Phalacroma parvulum*, P; *Dinophysis caudata*, 9%; *D. hastata*, 1%; *Amphisolenia globifera*, 1%; *Triposolenia bicornis*, 2%.

4574

Lat. 30° 35′ N., long. 117° 15′ W. October 8, 1904. Temperature, 69°.

Surface: *Phalacroma parvulum*, 1%; *Dinophysis caudata*, 1%.

300 fathoms to surface: — *Dinophysis caudata*, 2%; *D. schröderi*, P; *Amphisolenia bidentata*, P; *A. quadrispina*, 1%; *Triposolenia bicornis*, 1%.

4580

Lat. 24° 55′ N., long. 112° 45′ W. October 10, 1904. Temperature, 76°.

Surface: — *Dinophysis caudata*, P.

300 fathoms to surface: — *Phalacroma parvulum*, 1%; *P. rapa*, P; *Dinophysis caudata*, P; *D. hastata*, 1%; *Amphisolenia bidentata*, 1%; *A. extensa*, P; *A. quadrispina*, P; *Triposolenia bicornis*, 1%; *T. depressa*, P; *T. intermedia*, P; *T. longicornis*, P; *T. ramiciformis*, P; *T. truncata*, P; *Ornithocercus quadratus*, 2%.

4583

Lat. 22° 45′ N., long. 110° 5′ W. October 11, 1904. Temperature, 83°.

Surface: — *Phalacroma doryphorum*, P; *Dinophysis caudata*, P; *D. hastata*, P; *Amphisolenia bidentata*, 1%; *Ornithocercus magnificus*, P; *O. quadratus*, P; *O. thurni*, P.

300 fathoms to surface: — *Phalacroma argus*, P; *P. cuneus*, P; *P. rapa*, P; *Dinophysis caudata*, P; *D. hastata*, P; *Amphisolenia bidentata*, 2%; *A. bifurcata*, P; *A. bispinosa*, P; *A. extensa*, 1%; *A. quadrispina*, P; *Triposolenia bicornis*, 1%; *T. intermedia*, P; *T. longicornis*, P; *T. ramiciformis*, P; *T. truncata*, P; *Ornithocercus magnificus*, 2%; *O. quadratus*, 1%; *O. splendidus*, P; *O. steini*, P; *O. thurni*, P.

4587

Lat. 20° 42′ N., long. 107° 25′ W. October 12, 1904. Temperature, 82°.

300 fathoms to surface: — *Phalacroma cuneus*, P; *P. doryphorum*, P; *P. favus*, P; *P. ovum*, P; *P. porodictyum*, P; *P. rapa*, P; *Dinophysis hastata*, 1%; *D. schütti*, P; *Amphisolenia bidentata*, 3%; *A. extensa*, P; *A. lemmermanni*, P; *A. palmata*, P; *A. rectangulata*, P; *A. schauinslandi*, P; *A. thrinax*, P; *Triposolenia ambulatrix*, P; *T. fatula*, P; *T. ramiciformis*, P; *Ornithocercus magnificus*, P; *O. quadratus*, 2%; *O. splendidus*, P; *O. steini*, P; *O. thurni*, P.

4588

Lat. 19° 52′ N., long. 106° 22′ W. October 12, 1904. Temperature, 81°–83°.

Surface: — *Phalacroma doryphorum*, P; *Dinophysis caudata*, 1%; *D. hastata*, P; *Amphisolenia bidentata*, P; *A. schauinslandi*, P; *Ornithocercus magnificus*, 3%; *O. quadratus*, P.

Salpa stomach: — *Phalacroma doryphorum*, one specimen; *Dinophysis uracantha*, one specimen; *Ornithocercus heteroporus*, one specimen; *O. magnificus*, two specimens; *O. thurni*, one specimen.

Only fourteen specimens of dinoflagellates were recorded.

4590

Lat. 18° 50′ N., long. 104° 50′ W. October 13, 1904. Temperature, 82°–83°.

Surface: — *Phalacroma rapa*, P; *Ornithocercus magnificus*, 7%; *O. steini*, 1%; *O. thurni*, 1%.

300 fathoms to surface: — *Phalacroma cuneus*, 1%; *P. doryphorum*, 4%; *P. favus*, P; *P. porodictyum*, P; *P. rapa*, P; *Dinophysis hastata*, P; *D. uracantha*, 1%;

Amphisolenia bidentata, 3%; *A. globifera*, P; *A. lemmermanni*, 2%; *A. schauinslandi*, 1%; *A. thrinax*, 1%; *Triposolenia ramiciformis*, P; *Ornithocercus carolinae*, P; *O. heteroporus*, P; *O. magnificus*, 4%; *O. quadratus*, 4%; *O. steini*, P; *O. thurni*, P; *Histioneis hippoperoides*, P; *H. pulchra*, 1%; *Citharistes apsteini*, P.

4592

Lat. 18° 20′ N., long. 103° 40′ W. October 13, 1904. Temperature, 84°.

Surface: — *Phalacroma doryphorum*, P; *P. favus*, P; *Dinophysis uracantha*, 1%; *Amphisolenia bidentata*, 2%; *Ornithocercus magnificus*, 2%; *O. quadratus*, P; *O. steini*, P; *O. thurni*, 2%.

4594

Lat. 17° 20′ N., long. 101° 32′ W. October 14, 1904. Temperature, 84°.

300 fathoms to surface: — *Phalacroma cuneus*, 1%; *P. doryphorum*, P; *P. favus*, P; *P. rapa*, P; *Dinophysis caudata*, P; *D. hastata*, P; *Amphisolenia bidentata*, P; *A. extensa*, P; *A. lemmermanni*, P; *A. thrinax*, 1%; *Triposolenia fatula*, P; *T. longicornis*, P; *Ornithocercus magnificus*, P; *O. quadratus*, 1%; *O. thurni*, P.

4596

Lat. 16° 47′ N., long. 100° 27′ W. October 14, 1904. Temperature, 84°.

Surface: — *Phalacroma doryphorum*, P; *P. rapa*, P; *Dinophysis caudata*, P; *D. hastata*, P; *Amphisolenia bidentata*, 1%; *Ornithocercus magnificus*, 5%; *O. quadratus*, 1%; *O. thurni*, 2%.

4598

Lat. 15° 58′ N., long. 98° 13′ W. October 15, 1904. Temperature, 84°.

300 fathoms to surface: — *Phalacroma cuneus*, 1%; *P. doryphorum*, 3%; *P. porodictyum*, P; *P. rapa*, 1%; *Dinophysis caudata*, 2%; *D. jörgenseni*, P; *Amphisolenia extensa*, 1%; *A. schröderi*, P; *Triposolenia ambulatrix*, 1%; *T. bicornis*, P; *T. fatula*, 1%; *T. longicornis*, P; *T. ramiciformis*, 1%; *Ornithocercus magnificus*, 3%; *O. quadratus*, P; *O. steini*, 15%; *O. thurni*, 4%; *Parahistioneis reticulata*, 1%.

4600

Lat. 15° 36′ N., long. 97° 0′ W. October 15, 1904. Temperature, 82°.

Surface: — *Phalacroma doryphorum*, 1%; *P. rapa*, 1%; *Dinophysis caudata*, P; *Ornithocercus magnificus*, 5%; *O. quadratus*, 3%; *O. steini*, 6%; *O. thurni*, 2%.

4604

Lat. 12° 21′ N., long. 92° 13′ W. October 17, 1904. Temperature, 84°.

Surface: — *Phalacroma doryphorum*, 3%; *P. favus*, 1%; *P. rapa*, P; *Dinophysis caudata*, P; *Ornithocercus magnificus*, 13%; *O. quadratus*, 6%; *O. steini*, 1%; *O. thurni*, 7%; *O.* sp. indet., division stage, P; *Parahistioneis reticulata*, P; *Histioneis costata*, P.

4605

Lat. 12° 21′ N., long. 92° 13′ W. October 17, 1904. Temperature, 85°.

300 fathoms to surface: — *Phalacroma cuneus*, P; *P. doryphorum*, 1%; *P. porodictyum*, P; *P. rapa*, P; *Dinophysis caudata*, P; *D. hastata*, P; *D. uracantha*, P;

Amphisolenia bidentata, 1%; *A. bispinosa*, P; *A. curvata*, P; *A. extensa*, P; *A. lemmermanni*, P; *A. quadrispina*, P; *A. schröderi*, P; *Triposolenia bicornis*, 1%; *T. ramiciformis*, P; *Ornithocercus magnificus*, 2%; *O. quadratus*, 4%; *O. steini*, 8%; *O. thurni*, P; *O.* sp. indet., P; *O.* sp. indet., division stage, P.

4607

Lat. 12° 0′ N., long. 91° 30′ W. October 17, 1904. Temperature, 83°.

Surface: — *Phalacroma rapa*, P; *Ornithocercus magnificus*, 4%; *O. quadratus*, 15%; *O. steini*, 14%; *O. thurni*, 10%.

4609

Lat. 11° 05′ N., long. 89° 35′ W. October 18, 1904. Temperature, 81°.

300 fathoms to surface: — *Phalacroma cuneus*, 2%; *P. doryphorum*, P; *P. rapa*, P; *Dinophysis caudata*, 2%; *D. jörgenseni*, P; *Amphisolenia bidentata*, 1%; *Triposolenia bicornis*, P; *Ornithocercus magnificus*, 8%; *O. quadratus*, P; *O. steini*, P; *O. thurni*, 4%.

4611

Lat. 10° 33′ N., long. 88° 30′ W. October 18, 1904. Temperature 78°.

Surface: — *Phalacroma doryphorum*, P; *Dinophysis caudata*, 29%; *Ornithocercus magnificus*, P; *O. steini*, P.

4613

Lat. 9° 45′ N., long. 86° 20′ W. October 19, 1904. Temperature, 80°.

300 fathoms to surface: — *Phalacroma cuneus*, 6%; *P. doryphorum*, 1%; *P. fimbriatum*, P; *P. porodictyum*, P; *P. rapa*, 1%; *Dinophysis caudata*, 1%; *D. hastata*, P; *D. jörgenseni*, 1%; *Amphisolenia bidentata*, 1%; *A. extensa*, P; *A. globifera*, 1%; *A. quadrispina*, P; *Triposolenia bicornis*, 1%; *T. depressa*, P; *T. intermedia*, P; *T. ramiciformis*, P; *T. truncata*, P; *Ornithocercus carolinae*, P; *O. magnificus*, 5%; *O. splendidus*, P; *O. steini*, 12%; *O. thurni*, 16%.

4615

Lat. 9° 7′ N., long. 85° 11′ W. October 19, 1904. Temperature, 80°.

Surface: — *Phalacroma rapa*, 2%; *Dinophysis caudata*, 6%; *Ornithocercus magnificus*, 2%; *O. quadratus*, 3%; *O. steini*, 4%; *O. thurni*, 10%.

4617

Lat. 7° 45′ N., long. 82° 25′ W. October 20, 1904. Temperature, 78°.

Surface: — *Phalacroma doryphorum*, 1%; *P. favus*, P; *P. rapa*, P; *Ornithocercus magnificus*, 2%; *O. quadratus*, P; *O. orbiculatus*, P; *O. steini*, 1%; *O. thurni*, 5%.

300 fathoms to surface: — *Phalacroma cuneus*, P; *P. favus*, P; *P. ovum*, P; *P. rapa*, 1%; *Dinophysis caudata*, 1%; *Amphisolenia bidentata*, 1%; *A. bispinosa*, P; *A. quadrispina*, 1%; *A. rectangulata*, P; *Triposolenia bicornis*, 1%; *T. longicornis*, 1%; *T. truncata*, P; *Ornithocercus magnificus*, 5%; *O. quadratus*, 1%; *O. steini*, 8%; *O. thurni*, 2%.

4619

Lat. 7° 15′ N., long. 82° 8′ W. October 20, 1904. Temperature, 79°.

Surface: — *Phalacroma rapa*, 1%; *Ornithocercus magnificus*, 6%; *O. quadratus*, 2%; *O. steini*, 2%; *O. thurni*, 23%; *O.* sp. indet., P; *O.* sp. indet., division stage, P.

Salpa stomach: — *Phalacroma doryphorum*, 5%; *P. lativelatum*, 1%; *Dinophysis sphaerica*, 1%; *Ornithocercus magnificus*, 4%; *O. quadratus*, 4%; *O. steini*, 1%; *O. thurni*, 37%; *Parahistioneis diomedeae*, 2%; *P. karsteni*, P; *Histioneis costata*, 4%.

4623

Lat. 6° 58′ N., long. 80° 46′ W. October 21, 1904. Temperature, 78°–81°.

Surface: — *Amphisolenia lemmermanni*, P; *Ornithocercus steini*, P; *O. thurni*, P; *Histioneis dolon*, P.

4624

Lat. 6° 58′ N., long. 80° 46′ W. October 21, 1904. Temperature, 79°.

Surface: — *Phalacroma rapa*, 2%; *Ornithocercus magnificus*, 2%.

4627

Lat. 7° 21′ N., long. 79° 55′ W. November 2, 1904. Temperature, 81.5°.

Surface: — *Ornithocercus magnificus*, 2%.

4631

Lat. 6° 26′ N., long. 81° 49′ W. November 3, 1904. Temperature, 82°.

Surface: — *Phalacroma doryphorum*, P; *Dinophysis caudata*, P; *Ornithocercus magnificus*, 2%; *O. quadratus*, P; *O. thurni*, 2%.

4634

Lat. 4° 35′ N., long. 83° 32′ W. November 4, 1904. Temperature, 80°.

300 fathoms to surface: — *Phalacroma cuneus*, 2%; *P. doryphorum*, 1%; *P. porodictyum*, 1%; *P. rapa*, P; *P. striatum*, P; *Dinophysis caudata*, P; *D. hastata*, 1%; *Amphisolenia bidentata*, P; *A. extensa*, P; *A. quadrispina*, P; *Triposolenia ramiciformis*, P; *T. truncata*, 1%; *Ornithocercus magnificus*, 7%; *O. quadratus*, 3%; *O. steini*, 3%; *O. thurni*, 2%.

4635

Lat. 3° 52′ N., long. 84° 14′ W. November 4, 1904. Temperature, 79°.

Surface: — *Phalacroma parvulum*, 1%; *P. rapa*, P; *Ornithocercus magnificus*, 9%; *O. quadratus*, P; *O. steini*, 4%; *Citharistes apsteini*, P.

4637

Lat. 1° 31′ N., long. 86° 32′ W. November 5, 1904. Temperature, 76°.

300 fathoms to surface: — *Phalacroma argus*, P; *P. cuneus*, P; *P. doryphorum*, 1%; *P. porodictyum*, P; *P. rapa*, P; *P. striatum*, P; *Dinophysis caudata*, 1%; *D. hastata*, P; *D. jörgenseni*, P; *D. uracantha*, P; *Triposolenia bicornis*, P; *T. ramiciformis*, P; *T. truncata*, 1%; *Ornithocercus magnificus*, 6%; *O. quadratus*, 1%; *O. steini*, 3%; *O. thurni*, P; *O.* sp. indet., P.

4638

Lat. 0° 27′ N., long. 87° 13′ W. November 6, 1904. Temperature, 75°.

Surface: — *Dinophysis caudata*, P; *Amphisolenia bidentata*, 1%; *Ornithocercus magnificus*, 2%; *O. quadratus*, 4%; *O. steini*, 1%; *O. thurni*, 2%.

300 fathoms to surface: — *Phalacroma circumsutum*, 1%; *P. cuneus*, 1%; *P. mucronatum*, 2%; *P. striatum*, P; *Dinophysis caudata*, 2%; *D. hastata*, P; *D. norvegica* (?), 1%; *D. swezyi*, P; *D. uracantha*, 1%; *Amphisolenia bidentata*, 1%; *A. extensa*, 2%; *Triposolenia bicornis*, P; *T. truncata*, P; *Ornithocercus magnificus*, 4%; *O. quadratus*, 7%; *O. steini*, 7%; *O. thurni*, 6%; *O.* sp. indet., P.

4639

Lat. 0° 4′ S., long. 87° 39′ W. November 6, 1904. Temperature, 76°.

Surface: — *Dinophysis caudata*, 9%; *Ornithocercus magnificus*, 2%; *O. quadratus*, P; *O. steini*, 1%.

4640

Lat. 0° 39′ S., long. 88° 11′ W. November 6, 1904. Temperature, 75°.

Surface: — *Phalacroma rapa*, P; *Dinophysis caudata*, 5%; *Amphisolenia bidentata*, 1%; *Ornithocercus magnificus*, 1%; *O. quadratus*, 1%; *O. steini*, 3%; *O. thurni*, 1%.

4644

Lat. 2° 13′ S., long. 89° 42′ W. November 7, 1904. Temperature, 72°.

Surface: — *Phalacroma doryphorum*, P; *P. rapa*, P; *Dinophysis caudata*, 2%; *Ornithocercus magnificus*, 1%; *O. steini*, P; *O. thurni*, P.

4646

Lat. 4° 1′ S., long. 89° 16′ W. November 8, 1904. Temperature, 72°.

Surface: — *Ornithocercus steini*, P; *O. thurni*, P.

Salpa stomach: — *Ornithocercus thurni*, two specimens.

Only six specimens of dinoflagellates were recorded.

300 fathoms to surface: — *Phalacroma doryphorum*, P; *Amphisolenia bidentata*, 1%; *Ornithocercus magnificus*, 2%; *O. quadratus*, P; *O. steini*, P; *O. thurni*, P.

4647

Lat. 4° 33′ S., long. 87° 42′ W. November 9, 1904. Temperature, 70°.

800 fathoms to surface: — *Phalacroma cuneus*, P; *P. doryphorum*, 1%; *Dinophysis caudata*, 1%; *D. uracantha*, P; *Ornithocercus magnificus*, P; *O. quadratus*, P; *O. steini*, P; *O. thurni*, 1%.

4648

Lat. 4° 43′ S., long. 87° 7′ W. November 9, 1904. Temperature, 71°.

Surface: — *Phalacroma doryphorum*, P; *Amphisolenia bidentata*, 1%; *Ornithocercus steini*, 2%.

300 fathoms to surface: — *Phalacroma doryphorum*, 1%; *P. parvulum*, 1%; *P. porodictyum*, 1%; *Dinophysis uracantha*, 1%; *Amphisolenia bidentata*, 8%; *Triposolenia bicornis*, 1%; *T. ramiciformis*, 2%; *Ornithocercus magnificus*, 1%.

4649

Lat. 5° 17′ S., long. 85° 19′ W. November 10, 1904. Temperature, 70°.

Surface: — *Dinophysis caudata*, 11%.

4650

Lat. 5° 22′ S., long. 84° 39′ W. November 10, 1904. Temperature, 71°.

Surface: — *Phalacroma rapa*, 2%; *Dinophysis caudata*, 2%.

300 fathoms to surface: — *Phalacroma cuneus*, 1%; *P. doryphorum*, P; *P. rapa*, P; *Dinophysis caudata*, 3%; *D. hastata*, P; *D. jörgenseni*, P; *Amphisolenia extensa*, P; *Triposolenia bicornis*, P; *T. depressa*, 1%; *T. ramiciformis*, 1%; *T. truncata*, P; *Ornithocercus magnificus*, 2%; *O. quadratus*, P; *O. steini*, P.

4651

Lat. 5° 41′ S., long. 82° 59′ W. November 11, 1904. Temperature, 66°.

800 fathoms to surface: — *Phalacroma doryphorum*, 1%; *P. parvulum*, 1%; *Dinophysis caudata*, 2%; *D. hastata*, P; *D. jörgenseni*, P.

4652

Lat. 5° 44′ S., long. 82° 39′ W. November 11, 1904. Temperature, 66°.

100 fathoms to surface: — *Phalacroma argus*, P; *P. doryphorum*, P; *Dinophysis caudata*, P; *D. jörgenseni*, P; *D. schütti*, P; *Triposolenia bicornis*, 1%; *T. depressa*, P; *T. longicornis*, P; *T. ramiciformis*, P.

4655

Lat. 5° 57′ S., long. 80° 50′ W. November 12, 1904. Temperature, 65°.

400 and 300 fathoms to surface: — *Phalacroma argus*, 1%; *P. cuneus*, P; *P. doryphorum*, P; *P. reticulatum*, P; *Dinophysis caudata*, 2%; *D. jörgenseni*, P; *Dinofurcula ventralis*, P; *Triposolenia depressa*, 1%; *T. truncata*, P.

4657

Lat. 7° 12′ S., long. 84° 9′ W. November 13, 1904. Temperature, 69°.

Surface: — *Phalacroma cuneus*, 1%; *Dinophysis caudata*, 3%.

300 fathoms to surface: — *Phalacroma cuneus*, 1%; *P. ovum*, 1%; *Dinophysis caudata*, 1%; *Triposolenia bicornis*, 1%.

4659

Lat. 8° 54′ S., long. 86° 5′ W. November 14, 1904. Temperature, 69°.

Surface: — *Dinophysis caudata*, 3%.

300 fathoms to surface: — *Phalacroma doryphorum*, P; *Dinophysis caudata*, 12%; *D. hastata*, P; *D. jörgenseni*, P; *D. uracantha*, P; *Dinofurcula ventralis*, P; *Amphisolenia bidentata*, 2%; *A. schröderi*, P; *Triposolenia bicornis*, P; *T. depressa*, P; *T. longicornis*, P; *T. ramiciformis*, 1%; *Ornithocercus steini*, P.

4660

Lat. 9° 55′ S., long. 87° 30′ W. November 15, 1904. Temperature, 69°.

Salpa stomach: — *Phalacroma cuneus*, one specimen; *P. doryphorum*, four specimens; *Dinophysis caudata*, five specimens; *D.* sp. indet., one specimen. Only seventy-seven specimens of dinoflagellates were recorded.

4661

Lat. 10° 17′ S., long. 88° 2′ W. November 15, 1904. Temperature, 69°.

Salpa stomach: — *Phalacroma rapa*, one specimen; *Dinophysis* spp., four specimens.

Only fifty-six specimens of dinoflagellates were recorded.

300 fathoms to surface: — *Phalacroma cuneus*, P; *P. doryphorum*, P; *Dinofurcula ultima*, P.

4662

Lat. 11° 13′ S., long. 89° 35′ W. November 16, 1904. Temperature, 69°.

800 fathoms to surface: — *Phalacroma cuneus*, 4%; *P. doryphorum*, P; *P. lenticula*, P; *P. porodictyum*, P; *Amphisolenia bispinosa*, P; *A. globifera*, 1%; *Triposolenia depressa*, P; *T. longicornis*, P; *T. ramiciformis*, P.

4663

Lat. 11° 20′ S., long. 88° 52′ W. November 16, 1904. Temperature, 69°.

300 fathoms to surface: — *Phalacroma cuneus*, 10%; *P. doryphorum*, 5%; *Dinophysis caudata*, 1%; *D. jörgenseni*, 1%; *Triposolenia ramiciformis*, 2%.

4664

Lat. 11° 30′ S., long. 87° 19′ W. November 17, 1904. Temperature, 68°.

Surface: — *Phalacroma cuneus*, 1%.

Salpa stomach: — *Phalacroma cuneus*, one specimen; *P. doryphorum*, one specimen; *Ornithocercus thurni*, one specimen.

Only seven specimens of dinoflagellates were recorded.

300 fathoms to surface: — *Phalacroma argus*, P; *P. cuneus*, 40%; *P. doryphorum*, 3%; *P. lenticula*, P; *Dinophysis hastata*, P.

4665

Lat. 11° 45′ S., long. 86° 5′ W. November 17, 1904. Temperature, 68°.

300 fathoms to surface: — *Heteroschisma inaequale*, P; *Phalacroma cuneus*, 1%; *P. doryphorum*, P; *P. favus*, P; *P. rapa*, P; *Dinophysis hastata*, P; *D. jörgenseni*, P; *Triposolenia longicornis*, P; *T. ramiciformis*, P.

4666

Lat. 11° 55′ S., long. 84° 20′ W. November 18, 1904. Temperature, 67°.

Surface: — *Phalacroma rapa*, 1%; *Dinophysis caudata*, 1%; *D. hastata*, 1%.

800 fathoms to surface: — *Phalacroma cuneus*, 6%; *P. porodictyum*, P; *Dinophysis hastata*, P; *Amphisolenia globifera*, 1%; *Triposolenia ramiciformis*, 1%.

4667

Lat. 11° 59′ S., long. 83° 40′ W. November 18, 1904. Temperature, 68°.

300 fathoms to surface: — *Phalacroma cuneus*, 1%; *P. doryphorum*, 3%; *P. limbatum*, P; *Dinophysis caudata*, 1%; *D. fortii*, P; *Amphisolenia bidentata*, 1%; *A. extensa*, P; *A. lemmermanni*, P; *Triposolenia bicornis*, P; *T. depressa*, P; *T. longicornis*, P; *T. ramiciformis*, P.

4668

Lat. 12° 9′ S., long. 81° 45′ W. November 19, 1904. Temperature, 67°.

300 fathoms to surface: — *Phalacroma cuneus*, P; *Dinophysis caudata*, P; *Amphisolenia bispinosa*, 1%; *A. extensa*, P; *A. globifera*, 1%; *A. palaeotheroides*, P; *Triposolenia bicornis*, 1%; *T. longicornis*, P; *T. ramiciformis*, 1%.

4669

Lat. 12° 12′ S., long. 80° 25′ W. November 19, 1904. Temperature, 67°.

Surface: — *Phalacroma cuneus*, 4%; *P. doryphorum*, 2%; *Dinophysis caudata*, 10%.

4670

Lat. 12° 8′ S., long. 79° 2′ W. November 20, 1904. Temperature, 66°.

800 fathoms to surface: — *Phalacroma cuneus*, P; *Dinophysis caudata*, 1%; *Triposolenia bicornis*, P; *T. ramiciformis*, P.

4671

Lat. 12° 6′ S., long. 78° 28′ W. November 20, 1904. Temperature, 66°.

300 fathoms to surface: — *Heteroschisma aequale*, P; *Phalacroma circumcinctum*, P; *P. cuneus*, 3%; *P. doryphorum*, 1%; *Dinophysis caudata*, 2%; *D. collaris*, P; *D. uracantha*, 1%; *Dinofurcula ultima*, P; *Triposolenia bicornis*, 1%; *T. depressa*, P; *T. ramiciformis*, 1%; *Ornithocercus magnificus*, P; *O. quadratus*, P; *O. thurni*, P.

4673

Lat. 12° 30′ S., long. 77° 49′ W. November 21, 1904. Temperature, 67°.

300 fathoms to surface: — *Phalacroma porodictyum*; *Dinophysis caudata* f. *acutiformis; D. okamurai;* frequencies unknown.

4675

Lat. 12° 54′ S., long. 78° 33′ W. November 22, 1904. Temperature, 68°.

Surface: — *Phalacroma cuneus*, 2%; *P. doryphorum*, 2%.

300 fathoms to surface: — *Phalacroma cuneus*, P; *P. doryphorum*, 2%; *Dinophysis caudata*, 2%; *D. hastata*, P; *Triposolenia longicornis*, 1%; *T. ramiciformis*, P.

4676

Lat. 14° 28′ S., long. 81° 24′ W. December 5, 1904. Temperature, 69°.

Surface: — *Phalacroma doryphorum*, P; *P. rapa*, P; *Dinophysis caudata*, 3%; *D. hastata*, P; *D. schütti*, P; *Amphisolenia bidentata*, 1%.

800 and 300 fathoms to surface: — *Phalacroma cuneus*, P; *P. doryphorum*, 1%; *P. limbatum*, 1%; *P. porodictyum*, P; *Dinophysis caudata*, 2%; *D. hastata*, P; *D. schütti*, P; *D. uracantha*, P; *Triposolenia depressa*, P; *T. longicornis*, P; *T. ramiciformis*, P; *Ornithocercus splendidus*, P.

4677

Lat. 14° 37′ S., long. 81° 41′ W. December 5, 1904. Temperature, 68°.

Surface: — No species of Dinophysoidae.

4678

Lat. 16° 31′ S., long. 85° 3′ W. December 6, 1904. Temperature, 68°.

Surface: — *Phalacroma doryphorum*, P; *P. rapa*, P; *Dinophysis caudata*, P.

4679

Lat. 17° 26′ S., long. 86° 46′ W. December 7, 1904. Temperature, 69°.

300 fathoms to surface: — *Phalacroma argus*, P; *P. cuneus*, P; *P. doryphorum*, 1%; *P. lenticula*, P; *P. porodictyum*, 1%; *P. rapa*, P; *P. striatum*, P; *Dinophysis collaris*, P; *D. hastata*, P; *D. jörgenseni*, P; *D. schütti*, P; *D. swezyi*, P; *D. uracantha*, 1%; *Amphisolenia bidentata*, P; *A. extensa*, P; *Triposolenia bicornis*, P; *T. ramiciformis*, P; *Ornithocercus quadratus*, P; *O. splendidus*, P; *O. thurni*, 1%; *Histioneis gubernans*, P; *H. pulchra*, P.

4680

Lat. 17° 55′ S., long. 87° 42′ W. December 7, 1904. Temperature, 68°.

Surface: — *Phalacroma rapa*, P; *Dinophysis hastata*, P; *Ornithocercus thurni*, P.

Salpa stomach: — *Phalacroma rapa*, one specimen; *Histioneis longicollis*, one specimen; *Citharistes regius*, one specimen.

Only seventeen specimens of dinoflagellates were recorded.

4681

Lat. 18° 47′ S., long. 89° 26′ W. December 8, 1904. Temperature, 68°.

800 and 300 fathoms to surface: — *Phalacroma argus*, 2%; *P. cuneus*, 1%; *P. doryphorum*, P; *P. limbatum*, P; *P. mucronatum*, P; *P. ovum*, P; *P. porodictyum*, 1%; *P. porosum*, P; *P. rapa*, 1%; *P. reticulatum*, P; *P. striatum*, P; *P. turbineum*, P; *Dinophysis collaris*, P; *D. hastata*, 1%; *D. jörgenseni*, P; *D. schütti*, 1%; *D. urceolus*, P; *Dinofurcula ventralis*, P; *Amphisolenia elongata*, P; *A. inflata*, P; *Triposolenia bicornis*, P; *T. depressa*, P; *T. ramiciformis*, P; *Ornithocercus carolinae*, P; *O. heteroporus*, P; *O. quadratus*, 3%; *O. splendidus*, 3%; *O. thurni*, 2%; *Histioneis carinata* (?), P; *H. dolon*, P; *H. pulchra*, P; *H. reginella*, P; *Citharistes apsteini*, P.

4682

Lat. 19° 7′ S., long. 90° 10′ W. December 8, 1904. Temperature, 69°.

Surface: — *Ornithocercus quadratus*, P; *O. thurni*, 2%.

4683

Lat. 20° 2′ S., long. 91° 52′ W. December 9, 1904. Temperature, 70°.

300 fathoms to surface: — *Phalacroma argus*, P; *P. cuneus*, P; *P. doryphorum*, P; *P. rapa*, P; *Dinophysis hastata*, P; *D. schütti*, P; *Amphisolenia extensa*, 1%; *Triposolenia bicornis*, P; *T. depressa*, P; *T. ramiciformis*, P; *Ornithocercus carolinae*, P; *O. quadratus*, P; *O. splendidus*, 1%; *O. thurni*, 4%; *Histioneis pulchra*, P.

4684

Lat. 20° 40′ S., long. 93° 19′ W. December 9, 1904. Temperature, 71°.

Surface: — *Ornithocercus thurni*, P.

4685

Lat. 21° 36′ S., long. 94° 56′ W. December 10, 1904. Temperature, 72°.

300 fathoms to surface: — *Phalacroma rapa*, P; *P. striatum*, P; *Triposolenia longicornis*, P; *Ornithocercus magnificus*, 1%; *O. quadratus*, P; *O. splendidus*, 1%; *O. thurni*, P; *Histioneis dolon*, P; *H. mitchellana*, P.

4686

Lat. 22° 2′ S., long. 95° 52′ W. December 10, 1904. Temperature, 71°.

Surface: — *Ornithocercus magnificus*, P; *O. thurni*, P.

4687

Lat. 22° 49′ S., long. 97° 30′ W. December 11, 1904. Temperature, 73°.

300 fathoms to surface: — *Phalacroma limbatum*, P; *Dinophysis hastata*, P; *D. schütti*, P; *Triposolenia bicornis*, P; *Ornithocercus magnificus*, 2%; *O. quadratus*, P; *O. splendidus*, 1%.

4688

Lat. 23° 17′ S., long. 98° 37′ W. December 11, 1904. Temperature, 72°.

Surface: — *Amphisolenia palmata*, 1%.

4689

Lat. 24° 5′ S., long. 100° 20′ W. December 12, 1904. Temperature, 72°.

800 and 300 fathoms to surface: — *Phalacroma cuneus*, 2%; *P. doryphorum*, 2%; *P. hindmarchi*, 1%; *P. porodictyum*, 1%; *P. rapa*, 1%; *Dinophysis hastata*, 2%; *D. schütti*, 1%; *Amphisolenia bidentata*, 3%; *A. palaeotheroides*, 1%; *Ornithocercus magnificus*, 6%; *O. quadratus*, 2%; *O. splendidus*, 2%; *O. thurni*, 1%; *Histioneis dolon*, P; *H. pulchra*, P.

4691

Lat. 25° 27′ S., long. 103° 29′ W. December 13, 1904. Temperature, 73°.

300 fathoms to surface: — *Phalacroma argus*, 1%; *P. cuneus*, P; *P. doryphorum*, 1%; *P. hindmarchi*, P; *P. porodictyum*, P; *P. rapa*, P; *Dinophysis hastata*, P; *D. monacantha*, P; *D. nias*, P; *D. similis*, P; *D. schütti*, P; *D. uracantha*, P; *Amphisolenia bidentata*, 1%; *A. bifurcata*, P; *A. extensa*, P; *A. lemmermanni*, 1%; *A. palaeotheroides*, P; *A. thrinax*, P; *Triposolenia ramiciformis*, P; *Ornithocercus carolinae*, P; *O. heteroporus*, P; *O. magnificus*, 5%; *O. quadratus*, 2%; *O. splendidus*, P; *O. thurni*, 1%; *O.* sp. indet., division stage, P; *Histioneis dolon*, P; *H. mitchellana*, P; *H. pulchra*, P.

4692

Lat. 25° 40′ S., long. 104° 1′ W. December 13, 1904. Temperature, 73°.

Surface: — *Phalacroma rapa*, P; *Ornithocercus magnificus*, 5%; *O. steini*, 2%; *O. thurni*, P.

4694

Lat. 26° 34′ S., long. 108° 57′ W. December 22, 1904. Temperature, 72°.

Surface: — *Amphisolenia bidentata*, P.

4695

Lat. 25° 22′ S., long. 107° 45′ W. December 23, 1904. Temperature, 74°.

300 fathoms to surface: — *Phalacroma argus*, P; *P. cuneus*, P; *P. doryphorum*, 1%; *P. giganteum*, P; *P. rapa*, 3%; *P. reticulatum*, P; *Dinophysis hastata*, P; *D. schütti*, 2%; *Amphisolenia bidentata*, 1%; *A. bifurcata*, P; *A. quadricauda*, P; *Ornithocercus carolinae*, P; *O. magnificus*, 9%; *O. quadratus*, 1%; *O. splendidus*, 1%; *O. thurni*, 2%; *Histioneis dolon*, P; *H. josephinae*, P; *H. mitchellana*, P; *Citharistes apsteini*, P.

4696

Lat. 24° 40′ S., long. 107° 5′ W. December 23, 1904. Temperature, 74°.

Surface: — *Ornithocercus magnificus*, 9%; *O. thurni*, 5%.

4697

Lat. 23° 24′ S., long. 106° 2′ W. December 24, 1904. Temperature, 75°.

300 fathoms to surface: — *Phalacroma apicatum*, P; *P. cuneus*, P; *P. doryphorum*, 1%; *P. hindmarchi*, P; *P. porodictyum*, P; *P. rapa*, 2%; *P. reticulatum*, P; *Dinophysis hastata*, P; *D. schütti*, P; *D. sphaerica*, P; *D. uracantha*, P; *Amphisolenia bidentata*, 3%; *A. extensa*, P; *A. lemmermanni*, P; *A. palmata*, P; *A. thrinax*, P; *Triposolenia bicornis*, P; *Ornithocercus formosus*, P; *O. magnificus*, 4%; *O. quadratus*, 1%; *O. splendidus*, 2%; *O. thurni*, P; *Parahistioneis paraformis*, P; *P. reticulata*, P; *Histioneis dolon*, P; *H. josephinae*, P; *H. mitchellana*, P; *Citharistes apsteini*, P.

4698

Lat. 22° 50′ S., long. 105° 31′ S. December 24, 1904. Temperature, 75°.

Surface: — *Ornithocercus magnificus*, P.

4699

Lat. 21° 39′ S., long. 104° 29′ W. December 25, 1904. Temperature, 75°.

Salpa stomach: — *Heteroschisma aequale*, one specimen.

Only ten specimens of dinoflagellates were recorded.

300 fathoms to surface: — *Phalacroma cuneus*, P; *P. doryphorum*, 2%; *P. giganteum*, 1%; *P. hindmarchi*, P; *P. limbatum*, P; *P. porodictyum*, 1%; *P. pulchrum*, P; *P. rapa*, P; *P. reticulatum*, 1%; *P. striatum*, P; *Dinophysis hastata*, P; *D. schütti*, 1%; *D. uracantha*, P; *Amphisolenia bidentata*, P; *A. bifurcata*, P; *A. extensa*, P; *A. globifera*, P; *A. lemmermanni*, P; *A. palaeotheroides*, 1%; *A. schauinslandi*, P; *Triposolenia bicornis*, P; *Ornithocercus carolinae*, P; *O. heteroporus*, P; *O. magnificus*, 9%; *O. quadratus*, 1%; *O. splendidus*, P; *O. thurni*, 1%; *Parahistioneis diomedeae*, P; *P. para*, 1%; *P. reticulata*, P; *Histioneis dolon*, P; *H. highleyi*, P; *H. josephinae*, P; *H. milneri*, P; *H. mitchellana*, P; *H. pulchra*, P; *Citharistes apsteini*, P.

4700

Lat. 20° 28′ S., long. 103° 26′ W. December 25, 1904. Temperature, 74°.

Surface: — *Amphisolenia bidentata*, P; *A. palmata*, P; *Ornithocercus magnificus*, P; *O. thurni*, P.

4701

Lat. 19° 11′ S., long. 102° 24′ W. December 26, 1904. Temperature, 72°.

800 and 300 fathoms to surface: — *Heteroschisma aequale*, P; *Phalacroma argus*, P; *P. cuneus*, 1%; *P. doryphorum*, 1%; *P. hindmarchi*, P; *P. lenticula*, P; *P. porodictyum*, P; *P. pulchrum*, P; *P. rapa*, 1%; *P. reticulatum*, P; *P. striatum*, P; *Dinophysis caudata*, P; *D. hastata*, P; *D. jörgenseni*, P; *D. schütti*, 1%; *D. similis*, P; *D. uracantha*, P; *Amphisolenia bidentata*, 2%; *A. bifurcata*, P; *A. extensa*, 1%; *A. globifera*, P; *A. laticincta*, P; *A. lemmermanni*, P; *A. palaeotheroides*, P; *A. projecta*, P; *A. schauinslandi*, P; *A. schröderi*, P; *A. thrinax*, 1%; *Triposolenia bicornis*, P; *T. depressa*, P; *T. ramiciformis*, 1%; *Ornithocercus carolinae*, P; *O. formosus*, P; *O. heteroporus*, P; *O. magnificus*, 1%; *O. quadratus*, 2%; *O. splendidus*, 1%; *O. steini*, P; *O. thurni*, 2%; *O.* sp. indet., division stage, P; *Parahistioneis paraformis*, P; *P. reticulata*, P; *Histioneis biremis*, P; *H. dolon*, P; *H. helenae*, P; *H. mitchellana*, P; *H. navicula*, P; *H. pulchra*, P; *Citharistes apsteini*, P.

4702

Lat. 18° 39′ S., long. 102° 0′ W. December 26, 1904. Temperature, 73°.

Surface: — *Ornithocercus magnificus*, 1%; *O. splendidus*, P.

4704

Lat. 16° 55′ S., long. 100° 24′ W. December 27, 1904. Temperature, 73°.

Surface: — *Ornithocercus steini*, P.

4705

Lat. 15° 5′ S., long. 99° 19′ W. December 28, 1904. Temperature, 72°.

300 fathoms to surface: — *Phalacroma argus*, P; *P. cuneus*, P; *P. limbatum*, 1%; *P. porodictyum*, P; *P. pulchrum*, P; *P. rapa*, P; *P. striatum*, P; *Dinophysis caudata*, P; *D. hastata*, P; *D. schütti*, P; *D. uracantha*, P; *Amphisolenia bidentata*, P; *A. lemmermanni*, P; *Triposolenia bicornis*, P; *T. depressa*, P; *T. ramiciformis*, P; *Histiophysis rugosa*, P; *Ornithocercus carolinae*, P; *O. magnificus*, P; *O. quadratus*, 1%; *O. splendidus*, P; *O. steini*, P; *O. thurni*, 1%; *Histioneis helenae*, P; *H. highleyi*, P; *H. pulchra*, P.

4706

Lat. 14° 18′ S., long. 98° 45′ W. December 28, 1904. Temperature, 72°.

Salpa stomach: — *Phalacroma cuneus*, one specimen.

Only ten specimens of dinoflagellates were recorded.

4707

Lat. 12° 33′ S., long. 97° 42′ W. December 29, 1904. Temperature, 72°.

300 fathoms to surface: — *Phalacroma cuneus*, P; *P. doryphorum*, P; *P. striatum*, P; *Dinophysis hastata*, P; *Amphisolenia extensa*, 1%; *A. palaeotheroides*, P; *Triposolenia bicornis*, P; *T. ramiciformis*, P; *Ornithocercus carolinae*, P; *O. quadratus*, 1%; *O. splendidus*, P; *Histioneis highleyi*, P.

4708

Lat. 11° 40′ S., long. 96° 55′ W. December 29, 1904. Temperature, 72°.

Surface: — *Amphisolenia bidentata*, P.

4709

Lat. 10° 15′ S., long. 95° 40′ W. December 30, 1904. Temperature, 72°.

Salpa stomach: — *Phalacroma rapa*, one specimen; *Dinophysis exigua*, one specimen; *Ornithocercus quadratus*, one specimen; *Parahistioneis rotundata*, one specimen; *Citharistes regius*, two specimens. Only forty-eight specimens of dinoflagellates were recorded.

300 fathoms to surface: — *Phalacroma cuneus*, P; *P. doryphorum*, P; *P. ovum*, P; *P. porosum*, P; *P. rapa*, 5%; *P. reticulatum*, P; *Dinophysis jörgenseni*, P; *D. trapezium*, P; *Amphisolenia extensa*, 1%; *A. lemmermanni*, P; *A. palaeotheroides*, P; *Triposolenia bicornis*, P; *T. depressa*, P; *T. intermedia*, P; *T. longicornis*, P; *T. ramiciformis*, P; *Ornithocercus carolinae*, P; *O. quadratus*, 2%; *O. splendidus*, P; *O. steini*, P; *O. thurni*, P; *Histioneis biremis*, P; *H. pulchra*, P.

4711

Lat. 7° 47′ S., long. 94° 5′ W. December 31, 1904. Temperature, 75°.

300 fathoms to surface: — *Phalacroma contractum*, P; *P. cuneolus*, P; *P. cuneus*, P; *P. doryphorum*, P; *P. mucronatum*, P; *P. ovum*, P; *P. rapa*, P; *Dinophysis collaris*, P; *D. hastata*, P; *D. jörgenseni*, P; *D. schutti*, P; *D. sphaerica*, P; *D. uracantha*, P; *Dinofurcula ultima*, P; *Amphisolenia extensa*, P; *A. globifera*, P; *A. quadrispina*, P; *Triposolenia ambulatrix*, P; *T. bicornis*, P; *T. depressa*, P; *T. longicornis*, P; *T. ramiciformis*, P; *T. truncata*, P; *Ornithocercus quadratus*, P; *O. steini*, 1%; *Histioneis gubernans*, P; *H. longicollis*, P; *H. paulseni*, P; *H. pulchra*, P; *Parahistioneis reticulata*, P.

4712

Lat. 7° 5′ S., long. 93° 35′ W. December 31, 1904. Temperature, 74°.

Surface: — *Amphisolenia bidentata*, 1%; *Ornithocercus magnificus*, 1%; *O. quadratus*, P; *O. steini*, 2%.

Salpa stomach: — *Ornithocercus steini*, 1 specimen; *Citharistes regius*, one specimen. Only ninety-one specimens of dinoflagellates were recorded.

4713

Lat. 5° 35′ S., long. 92° 21′ W. January 1, 1905. Temperature, 73°.

300 and 150 fathoms to surface: — *Phalacroma cuneus*, 2%; *P. doryphorum*, 3%; *P. expulsum*, P; *P. lens*, P; *P. porodictyum*, P; *P. pulchrum*, P; *P. pyriforme*, P; *P. striatum*, P; *Dinophysis caudata*, P; *D. collaris*, P; *D. jörgenseni*, P; *D. schütti*, P; *Amphisolenia astragalus*, P; *A. bidentata*, 4%; *A. bispinosa*, P; *A. extensa*, P; *A. globifera*, 1%; *A. inflata*, P; *Triposolenia ambulatrix*, P; *T. bicornis*, 1%; *T. depressa*, P; *T. longicornis*, 1%; *T. ramiciformis*, P; *Ornithocercus magnificus*, P; *O. quadratus*, P; *O. steini*, P; *O. thurni*, 10%; *O.* sp. indet., division stage, P.

4714

Lat. 4° 19′ S., long. 91° 28′ W. January 1, 1905. Temperature, 75°.

Surface: — *Ornithocercus steini*, 5%; *O. thurni*, 2%.

4715

Lat. 2° 40′ S., long. 90° 19′ W. January 2, 1905. Temperature, 75°.

800 and 300 fathoms to surface: — *Phalacroma doryphorum*, 3%; *P. striatum*, P; *P. turbineum*, P; *Dinophysis caudata*, 1%; *D. jörgenseni*, 1%; *D. schütti*, P; *Triposolenia bicornis*, P; *T. ramiciformis*, 1%; *T. truncata*, 1%; *Ornithocercus quadratus*, 1%; *O. steini*, 2%; *O. thurni*, 7%.

4716

Lat. 2° 18′ S., long. 90° 2′ W. January 2, 1905. Temperature, 75°.

Surface: — *Dinophysis caudata*, 1%; *Ornithocercus magnificus*, 1%; *O. steini*, 1%; *O. thurni*, 2%.

4717

Lat. 5° 10′ S., long. 98° 56′ W. January 13, 1905. Temperature, 75°.

800 and 300 fathoms to surface: — *Phalacroma doryphorum*, P; *P. expulsum*, P; *P. lens*, P; *P. striatum*, P; *Dinophysis hastata*, P; *D. jörgenseni*, P; *D. uracantha*, P; *Amphisolenia bidentata*, 2%; *A. lemmermanni*, 1%; *A. globifera*, 1%; *Triposolenia bicornis*, P; *T. ramiciformis*, P; *T. truncata*, P; *Ornithocercus heteroporus*, P; *O. quadratus*, 1%; *O. splendidus*, P; *O. steini*, P; *O. thurni*, 2%; *Histioneis dolon*, P; *Citharistes regius*, P.

4718

Lat. 5° 32′ S., long. 99° 32′ W. January 13, 1905. Temperature, 76°.

Surface: — *Amphisolenia bidentata*, 1%; *Ornithocercus quadratus*, P; *O. steini*, P.

4719

Lat. 6° 28′ S., long. 101° 16′ W. January 14, 1905. Temperature, 75°.

300 fathoms to surface: — *Phalacroma cuneus*, P; *P. doryphorum*, 1%; *P. porodictyum*, 1%; *P. rapa*, P; *P. striatum*, P; *Dinophysis uracantha*, P; *Amphisolenia bidentata*, 4%; *A. extensa*, P; *A. lemmermanni*, 1%; *Triposolenia longicornis*, P; *Ornithocercus carolinae*, P; *O. quadratus*, P; *O. steini*, 2%; *O. thurni*, P; *Histioneis pulchra*, P.

4720

Lat. 7° 13′ S., long. 102° 31′ W. January 14, 1905. Temperature, 76°.

Surface: — *Amphisolenia bidentata*, 2%; *A. lemmermanni*, P; *Ornithocercus magnificus*, 2%; *Parahistioneis diomedeae*, P.

Salpa stomach: — *Phalacroma expulsum*, P; *P. doryphorum*, 1%; *Dinophysis sphaerica*, 4%; *Amphisolenia bidentata*, 1%; *Ornithocercus quadratus*, 4%; *O. steini*, 1%; *Parahistioneis rotundata*, 1%; *Histioneis hyalina*, P; *H. inclinata*, P; *H. inornata*, P; *H. striata*, P; *Citharistes apsteini*, P.

4721

Lat. 8° 7′ S., long. 104° 10′ W. January 15, 1905. Temperature, 75°.

800 and 300 fathoms to surface: — *Heteroschisma aequale*, P; *Phalacroma doryphorum*, P; *P. ovum*, P; *P. porodictyum*, P; *P. porosum*, 1%; *P. rapa*, 1%; *P. striatum*, P; *Dinophysis hastata*, P; *D. uracantha*, P; *Amphisolenia bidentata*, 2%; *A. extensa*, 1%; *A. globifera*, P; *Triposolenia bicornis*, P; *T. depressa*, P; *T. longicornis*, P; *T. ramiciformis*, P; *Ornithocercus carolinae*, P; *O. magnificus*, P; *O. quadratus*, 7%; *O. splendidus*, P; *O. steini*, 11%; *O. thurni*, P; *O.* sp. indet., division stage, P; *Histioneis highleyi*, P; *H. pulchra*, P.

4722

Lat. 9° 31′ S., long. 106° 30′ W. January 16, 1905. Temperature, 75°.

300 fathoms to surface: — *Phalacroma argus*, P; *P. doryphorum*, 1%; *P. limbatum*, P; *P. rapa*, P; *P. striatum*, P; *Dinophysis hastata*, P; *D. schütti*, P; *D. triacantha*, P; *D. uracantha*, 1%; *Amphisolenia bidentata*, 1%; *A. extensa*, P; *A. globifera*, P; *A. lemmermanni*, P; *A. quadrispina*, P; *A. schauinslandi*, P; *Triposolenia bicornis*, P; *T. ramiciformis*, P; *Ornithocercus carolinae*, P; *O. formosus*, P; *O. heteroporus*, P; *O. magnificus*, P; *O. quadratus*, 4%; *O. splendidus*, 1%; *O. steini*, 7%; *O. thurni*, P; *O.* sp. indet., P; *Parahistioneis paraformis*, P; *P. reticulata*, 1%; *Histioneis biremis*, P; *H. elongata*, P; *H. highleyi*, P; *H. milneri*, P; *H. mitchellana*, P; *H. pulchra*, P.

4723

Lat. 10° 14′ S., long. 107° 45′ W. January 16, 1905. Temperature, 76°.

Salpa stomach: — *Amphisolenia bidentata*, one specimen; *A. lemmermanni*, one specimen; *Ornithocercus quadratus*, three specimens; *O. steini*, three specimens.

Only fifty-eight specimens of dinoflagellates were recorded.

4724

Lat. 11° 13′ S., long. 109° 39′ W. January 17, 1905. Temperature, 79°.

800 and 300 fathoms to surface: — *Phalacroma argus*, P; *P. cuneus*, P; *P. doryphorum*, P; *P. expulsum*, P; *P. lenticula*, P; *P. ovum*, P; *P. parvulum*, P; *P. porodictyum*, P; *P. rapa*, P; *P. reticulatum*, P; *P. striatum*, P; *Dinophysis hastata*, 1%; *D. uracantha*, P; *Amphisolenia bidentata*, 2%; *A. bifurcata*, P; *A. extensa*, P; *A. globifera*, P; *A. inflata*, P; *A. lemmermanni*, P; *Triposolenia bicornis*, 1%; *T. depressa*, P; *T. ramiciformis*, P; *T. truncata*, P; *Ornithocercus carolinae*, P; *O. formosus*, P; *O. heteroporus*, P; *O. magnificus*, P; *O. quadratus*, 5%; *O. splendidus*, 4%; *O. steini*, 1%; *O. thurni*, P; *Parahistioneis diomedeae*, P; *P. paraformis*, P; *Histioneis biremis*, P; *H. carinata*, P; *H. dolon*, P; *H. milneri*, P; *H. mitchellana*, P; *H. panaria*, P; *H. panda*, P; *H. pulchra*, P.

4725

Lat. 11° 38′ S., long. 110° 5′ W. January 17, 1905. Temperature, 77°.

Surface: — *Amphisolenia bidentata*, 2%; *A. schauinslandi*, P; *Ornithocercus magnificus*, 1%; *O. quadratus*, P.

Salpa stomach: — *Phalacroma rapa*, one specimen; *Ornithocercus quadratus*, one specimen; *Parahistioneis rotundata*, one specimen; *Histioneis dolon*, one specimen; *H. striata*, one specimen. Only fifty-four specimens of dinoflagellates were recorded.

4727

Lat. 13° 3′ S., long. 112° 44′ W. January 18, 1905. Temperature, 77°.

Surface: — *Dinophysis jörgenseni*, P; *Amphisolenia bidentata*, P; *Ornithocercus magnificus*, P; *O. steini*, P; *O. thurni*, P.

4728

Lat. 13° 47′ S., long. 114° 21′ W. January 19, 1905. Temperature, 77°.

Salpa stomach: — *Histioneis inclinata*, one specimen.

Only thirty specimens of dinoflagellates were recorded.

800 and 300 fathoms to surface: — *Phalacroma cuneus*, P; *P. doryphorum*, P; *Dinophysis uracantha*, P; *D.* sp. indet., 1%; *Amphisolenia asymmetrica*, P; *A. bidentata*, 3%; *A. extensa*, P; *A. lemmermanni*, P; *A. palaeotheroides*, P; *A. quadrispina*, P; *A. thrinax*, P; *Triposolenia bicornis*, P; *Ornithocercus carolinae*, P; *O. magnificus*, 2%; *O. quadratus*, 8%; *O. splendidus*, 1%; *O. steini*, P; *O. thurni*, 1%.

4729

Lat. 14° 15′ S., long. 114° 13′ W. January 19, 1905. Temperature, 78°.

Surface: — *Amphisolenia bidentata*, P; *Ornithocercus magnificus*, P; *O. quadratus*, P; *O. steini*, 1%.

4730

Lat. 15° 7′ S., long. 117° 1′ W. January 20, 1905. Temperature, 79°.

300 fathoms to surface: — *Phalacroma apicatum*, P; *P. argus*, P; *P. cuneus*, P; *P. doryphorum*, 1%; *P. favus*, P; *P. giganteum*, P; *P. hindmarchi*, P; *P. lens*, P; *P. mucronatum*, P; *P. ovum*, P; *P. porodictyum*, P; *P. porosum*, P; *P. protuberans*, P; *P. pulchrum*, P; *P. reticulatum*, P; *Dinophysis collaris*, P; *D. hastata*, P; *D. jörgenseni*, P; *D. monacantha*, P; *D. schütti*, P; *D. uracantha*, P; *Amphisolenia bidentata*, 1%; *A. lemmermanni*, P; *Triposolenia bicornis*, 1%; *T. depressa*, P; *T. truncata*, P; *Ornithocercus carolinae*, P; *O. heteroporus*, P; *O. magnificus*, P; *O. quadratus*, 2%; *O. splendidus*, P; *O. steini*, P; *O. thurni*, 4%; *Histioneis elongata*, P; *H. gubernans*, P; *H. helenae*, 1%; *H. highleyi*, P; *H. milneri*, P; *H. mitchellana*, 1%; *H. pulchra*, P.

4731

Lat. 15° 47′ S., long. 118° 22′ W. January 20, 1905. Temperature, 79.5°.

Surface: — *Phalacroma cuneus*, P; *P. hindmarchi*, 1%; *Amphisolenia bidentata*, 1%; *Ornithocercus magnificus*, 2%; *O. quadratus*, 1%; *O. steini*, 1%; *O. thurni*, P.

4732

Lat. 16° 32′ S., long. 119° 59′ W. January 21, 1905. Temperature, 79°.

800 and 300 fathoms to surface: — *Phalacroma apicatum*, P; *P. cuneus*, 1%;

P. doryphorum, P; *P. hindmarchi*, P; *P. porodictyum*, P; *P. porosum*, P; *P. reticulatum*, P; *P. striatum*, 1%; *Dinophysis hastata*, P; *D. jörgenseni*, P; *D. schütti*, P; *D. swezyi*, P; *D. uracantha*, P; *Amphisolenia asymmetrica*, 1%; *A. bidentata*, 1%; *A. extensa*, P; *A. globifera*, P; *A. lemmermanni*, P; *A. palaeotheroides*, P; *A. schauinslandi*, P; *A. thrinax*, P; *Triposolenia bicornis*, P; *T. depressa*, P; *T. truncata*, P; *Ornithocercus carolinae*, P; *O. heteroporus*, P; *O. magnificus*, 3%; *O. quadratus*, 1%; *O. splendidus*, 1%; *O. steini*, 1%; *O. thurni*, 1%; *Parahistioneis garretti*, P; *P. paraformis*, P; *Histioneis biremis*, 1%; *H. dolon*, P; *H. mitchellana*, 1%; *H. pulchra*, P.

4733

Lat. 16° 57′ S., long. 120° 48′ W. January 21, 1905. Temperature, 80°.

Surface: — *Phalacroma cuneus*, P; *Ornithocercus magnificus*, 3%; *O. quadratus*, 1%; *O. steini*, 2%; *O. thurni*, 1%; *O.* sp. indet., 1%.

Salpa stomach: — *Amphisolenia bidentata*, one specimen; *A. globifera*, one specimen; *A. truncata*, one specimen; *Ornithocercus heteroporus*, one specimen; *O.* sp. indet., one specimen; *Parahistioneis paraformis*, one specimen; *P. reticulata*, one specimen; *P. rotundata*, one specimen; *Histioneis gubernans*, one specimen; *H. navicula*, two specimens; *H. pacifica*, one specimen. Only eighty-eight specimens of dinoflagellates were recorded.

4734

Lat. 17° 36′ S., long. 122° 35′ W. January 22, 1905. Temperature, 81°.

300 fathoms to surface: — *Phalacroma apicatum*, P; *P. cuneus*, P; *P. doryphorum*, P; *P. giganteum*, P; *P. hindmarchi*, 1%; *P. porodictyum*, P; *P. porosum*, P; *Dinophysis hastata*, 1%; *D. uracantha*, P; *Amphisolenia bidentata*, 2%; *A. extensa*, P; *A. lemmermanni*, P; *A. palaeotheroides*, P; *A. palmata*, P; *A. rectangulata*, P; *A. schauinslandi*, P; *A. thrinax*, P; *Triposolenia bicornis*, P; *Ornithocercus carolinae*, P; *O. heteroporus*, P; *O. magnificus*, 3%; *O. quadratus*, 1%; *O. splendidus*, P; *O. steini*, P; *O. thurni*, 2%; *Parahistioneis paraformis*, P; *P. reticulata*, P; *Histioneis dolon*, P; *H. elongata*, P; *H. helenae*, P; *H. mitchellana*, P; *H. navicula*, P; *H. pulchra*, P.

4735

Lat. 18° 16′ S., long. 123° 34′ W. January 22, 1905. Temperature, 81°.

Surface: — *Amphisolenia schauinslandi*, P; *Ornithocercus magnificus*, 1%; *O. thurni*, P.

4736

Lat. 19°4′ S., long. 125° 5′ W. January 23, 1905. Temperature, 81°.

300 fathoms to surface: — *Phalacroma bipartitum*, P; *P. cuneus*, P; *P. hindmarchi*, P; *Dinophysis schütti*, P; *Amphisolenia bidentata*, 2%; *A. bispinosa*, P; *A. brevicauda*, P; *A. extensa*, P; *A. clavipes*, P; *A. schauinslandi*, P; *A. schröderi*, P; *A. thrinax*, P; *Ornithocercus magnificus*, 5%; *O. quadratus*, 1%; *O. splendidus*, P; *O. steini*, 1%; *O. thurni*, 1%; *Histioneis mitchellana*, P; *H. pulchra*, P.

4737

Lat. 19° 57′ S., long. 127° 20′ W. January 24, 1905. Temperature, 81.5°.

100 and 300 fathoms to surface: — *Phalacroma apicatum*, P; *P. cuneus*, P; *P. doryphorum*, 1%; *P. favus*, P; *P. hindmarchi*, P; *P. ovum*, P; *P. porodictyum*, P; *P. rapa*, P; *Dinophysis hastata*, 1%; *D. swezyi*, P; *Amphisolenia bidentata*, 3%; *A. bispinosa*, P; *A. clavipes*, P; *A. complanata*, P; *A. elongata*, P; *A. lemmermanni*, P; *A. palaeotheroides*, 1%; *A. palmata*, P; *A. quinquecauda*, P; *A. schauinslandi*, P; *A. schröderi*, P; *A. thrinax*, P; *Triposolenia bicornis*, P; *T. truncata*, P; *Ornithocercus carolinae*, 1%; *O. formosus*, P; *O. heteroporus*, P; *O. magnificus*, 3%; *O. quadratus*, 1%; *O. splendidus*, 2%; *O. steini*, 1%; *O. thurni*, 2%; *O.* sp. indet., division stage, P; *Histioneis biremis*, P; *H. dolon*, P; *H. gubernans*, P; *H. mitchellana*, P; *H. pulchra*, P; *Citharistes apsteini*, P.

4738

Lat. 20° 27′ S., long. 128° 30′ W. January 24, 1905. Temperature, 81°.

Surface: — *Amphisolenia bidentata*, 1%.

4739

Lat. 22° 11′ S., long. 133° 21′ W. January 26, 1905. Temperature, 79°.

300 fathoms to surface: — *Phalacroma cuneus*, 1%; *P. doryphorum*, 1%; *P. hindmarchi*, 1%; *P. porodictyum*, P; *P. reticulatum*, P; *P. rapa*, P; *Dinophysis hastata*, P; *D. uracantha*, P; *Amphisolenia asymmetrica*, P; *A. bidentata*, 6%; *A. complanata*, P; *A. extensa*, P; *A. quinquecauda*, P; *A. rectangulata*, P; *A. schauinslandi*, P; *A. schröderi*, P; *A. thrinax*, 1%; *Triposolenia bicornis*, 1%; *T. truncata*, P; *Ornithocercus carolinae*, P; *O. magnificus*, 2%; *O. quadratus*, 1%; *O. splendidus*, 3%; *O. steini*, P; *O. thurni*, 1%; *Histioneis josephinae*, P; *H. mitchellana*, P.

4740

Lat. 9° 2′ S., long. 123° 20′ W. February 11, 1905. Temperature, 81°.

Salpa stomach: — *Amphisolenia bidentata*, one specimen; *Ornithocercus magnificus*, one specimen. Only twenty-seven specimens of dinoflagellates were recorded.

800 and 300 fathoms to surface: — *Phalacroma argus*, P; *P. cuneus*, 2%; *P. doryphorum*, P; *P. lenticula*, P; *P. porosum*, P; *P. pulchrum*, P; *P. reticulatum*, P; *P. rapa*, P; *P. striatum*, P; *Dinophysis hastata*, 1%; *D. schütti*, P; *D. uracantha*, 1%; *Amphisolenia bidentata*, 4%; *A. brevicauda*, P; *A. extensa*, P; *A. laticincta*, P; *A. lemmermanni*, P; *A. palaeotheroides*, P; *A. rectangulata*, P; *A. schauinslandi*, P; *A. thrinax*, P; *Triposolenia bicornis*, P; *T. ramiciformis*, P; *T. truncata*, P; *Ornithocercus carolinae*, P; *O. magnificus*, 2%; *O. quadratus*, 10%; *O. splendidus*, 2%; *O. steini*, P; *O. thurni*, 4%; *Histioneis biremis*, P; *H. dolon*, P; *H. helenae*, P; *H. pulchra*, P.

4741

Lat. 8° 29′ S., long. 122° 56′ W. February 11, 1905. Temperature, 80°.

Surface: — *Phalacroma rapa*, P; *Dinophysis hastata*, P; *Amphisolenia bi-*

dentata, 2%; *A. lemmermanni*, P; *A. thrinax*, P; *Ornithocercus magnificus*, P; *O. quadratus*, 2%; *O. steini*, 4%; *O. thurni*, P.

Salpa stomach: — *Phalacroma favus*, one specimen; *Amphisolenia bidentata*, one specimen; *Ornithocercus steini*, one specimen; *Parahistioneis rotundata*, one specimen; *Histioneis longicollis*, one specimen; *H. pacifica*, one specimen; *Citharistes regius*, three specimens. Only thirty-four specimens of dinoflagellates were recorded.

4742

Lat. 0° 3′ S., long. 117° 15′ W. February 15, 1905. Temperature, 77°.

300 fathoms to surface: — *Phalacroma cuneus*, 3%; *P. doryphorum*, P; *P. giganteum*, P; *P. hindmarchi*, P; *P. praetextum*, P; *P. rapa*, P; *P. striatum*, 1%; *Dinophysis hastata*, 1%; *D. jörgenseni*, P; *Amphisolenia bidentata*, 1%; *A. extensa*, P; *A. globifera*, P; *A. lemmermanni*, P; *A. quadrispina*, P; *A. thrinax*, P; *Triposolenia bicornis*, 1%; *T. depressa*, P; *T. ramiciformis*, 1%; *T. truncata*, P; *Ornithocercus carolinae*, P; *O. heteroporus*, P; *O. magnificus*, P; *O. quadratus*, 10%; *O. splendidus*, 2%; *O. steini*, P; *O. thurni*, 1%; *O.* sp. indet., P; *Histioneis biremis*, P; *H. milneri*, P; *H. pulchra*, P.

4743

Lat. 0° 21′ N., long. 117° 2′ W. February 15, 1905. Temperature, 78°.

Surface: — *Phalacroma cuneus*, P; *P. doryphorum*, 1%; *P. rapa*, P; *Amphisolenia bidentata*, 1%; *A. thrinax*, P; *Ornithocercus carolinae*, P; *O. quadratus*, P; *O. splendidus*, P; *O. steini*, P; *O. thurni*, P; *Histioneis biremis*, P.

4540

Lat. 3° 25′ N., long. 115° 5′ W. February 17, 1905. Temperature, 79°.

Surface: — *Phalacroma argus*, P; *P. cuneus*, P; *P. doryphorum*, 1%; *Amphisolenia bidentata*, P; *Ornithocercus quadratus*, P; *O. splendidus*, P; *O. steini*, P; *O. thurni*, 2%.

4541

Lat. 4° 55′ N., long. 112° 27′ W. February 18, 1905. Temperature, 80°.

Surface: — *Phalacroma cuneus*, P; *P. doryphorum*, 1%; *Amphisolenia bidentata*, P; *Ornithocercus quadratus*, 1%; *O. splendidus*, 1%; *O. steini*, 1%; *O. thurni*, P; *Citharistes apsteini*, P.

4542

Lat. 7° 8′ N., long. 110° 45′ W. February 19, 1905. Temperature, 80°.

Surface: — *Phalacroma cuneus*, 3%; *P. doryphorum*, P; *P. favus*, 1%; *Dinophysis hastata*, 1%; *Amphisolenia bidentata*, P; *Ornithocercus magnificus*, 3%; *O. quadratus*, 1%; *O. steini*, 1%; *O. thurni*, P.

4543

Lat. 8° 52′ N., long. 108° 54′ W. February 20, 1905. Temperature, 79.5°.

Surface: — *Phalacroma doryphorum*, 1%; *Amphisolenia bidentata*, 1%; *Ornithocercus magnificus*, 2%; *O. quadratus*, 8%; *O. steini*, 13%.

4544

Lat. 10° 38′ N., long. 106° 47′ W. February 21, 1905. Temperature, 80°.

Surface: — *Dinophysis caudata*, 2%.

Salpa stomach: — *Ornithocercus magnificus*, two specimens. Only ten specimens of dinoflagellates were recorded.

4545

Lat. 12° 42′ N., long. 104° 45′ W. February 22, 1905. Temperature, 79°.

Surface: *Phalacroma cuneus*, 3%; *P. doryphorum*, 1%; *P. favus*, P; *Dinophysis caudata*, P; *D. exigua*, P; *Amphisolenia thrinax*, P; *Ornithocercus magnificus*, 5%; *O. quadratus*, 3%; *O. steini*, 10%.

4546

Lat. 14° 50′ N., long. 101° 31′ W. February 23, 1905. Temperature, 81°.

Surface: — *Phalacroma doryphorum*, 7%; *Dinophysis caudata*, P; *Ornithocercus magnificus*, 21%; *O. quadratus*, 6%; *O. steini*, 3%.

Acapulco Harbor, Mexico. February 26, 1905. Temperature, 83°.

Surface: — *Phalacroma cuneus*, 1%; *P. doryphorum*, 1%; *P. porodictyum*, P; *Dinophysis hastata*, P; *Amphisolenia bidentata*, P; *Ornithocercus magnificus*, P; *O. quadratus*, P; *O. thurni*, P.

Panama Harbor. October 25, 1904

Surface: — *Dinophysis caudata*, thirty specimens.

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EXPLANATION OF THE PLATES.

PLATE 1.

PLATE 1.

Fig. 1. *Heteroschisma inaequale*, sp. nov., right lateral view, somewhat tilted ventrally; type specimen. Station 4665 (300–0 fathoms). × 1090.

Fig. 2. The same, ventral view. Note that left sulcal list crosses over to right valve at level of posterior cingular list. × 1090.

Fig. 3. *Phalacroma porosum* Kofoid and Michener, oblique ventral view, somewhat tilted posteriorly; type specimen. Station 4721 (300–0 fathoms). × 525.

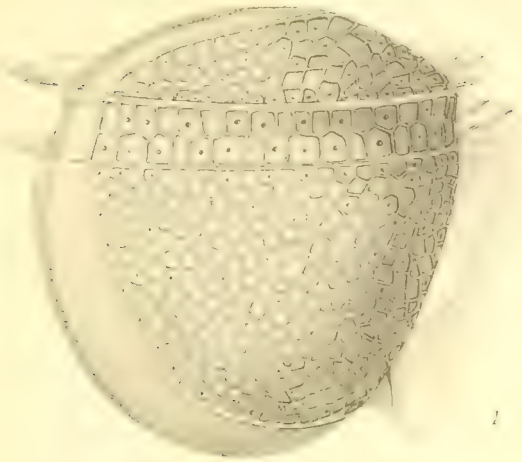
Fig. 4. *Phalacroma circumcinctum* Kofoid and Michener, ventral view; type specimen. Station 4671 (300–0 fathoms). The irregular, hyaline appendage, issuing from near the posterior main rib of left sulcal list is probably a temporary structure. × 665.

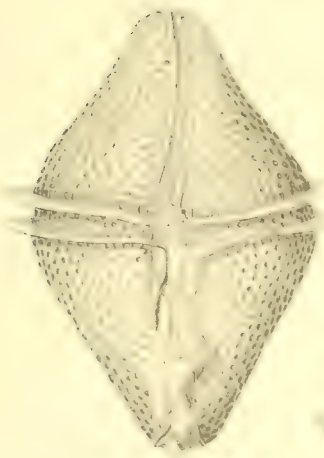
Fig. 5. The same, right lateral view. See explanation of Figure 4. × 665.

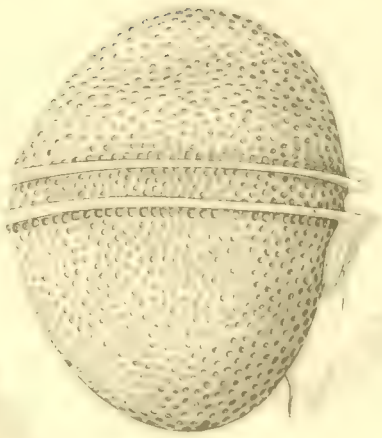
Fig. 6. *Phalacroma porosum* Kofoid and Michener, right lateral view; type specimen. Station 4721 (300–0 fathoms). × 1690.

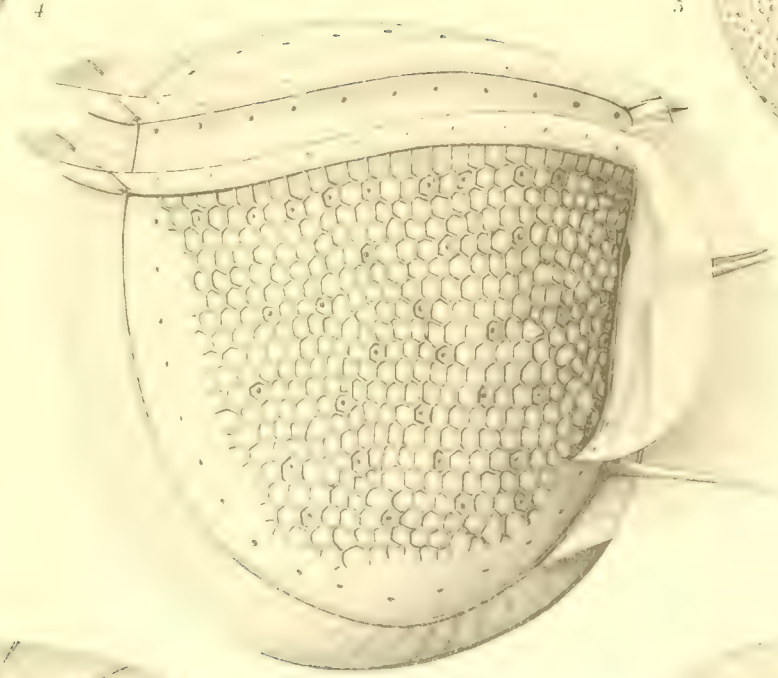
Fig. 7. *Heteroschisma aequale*, sp. nov., ventral view; type specimen. Station 4671 (300–0 fathoms). Note that left sulcal list crosses over to right valve at level of posterior cingular list × 1090.

Fig. 8. The same, right lateral view, tilted ventrally. × 1090.









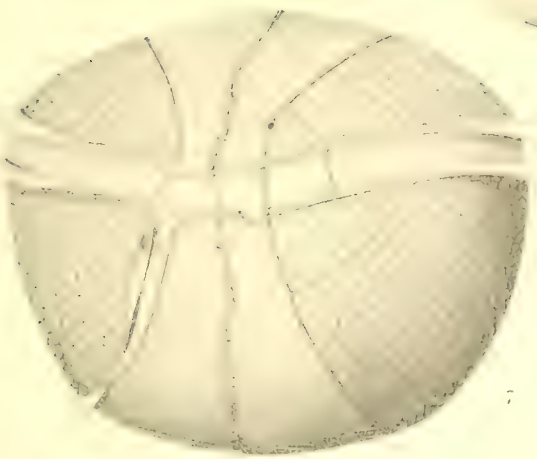


PLATE 2.

PLATE 2.

Fig. 1. *Phalacroma fimbriatum* Kofoid and Michener, ventral view; type specimen. Station 4613 (300–0 fathoms). Note the heavy rib that indicates the presence of a postcingular plate in the left hypotheca. × 580.

Fig. 2. *Phalacroma giganteum* Kofoid and Michener, right lateral view of right detached valve; type specimen. Station 4734 (300–0 fathoms). × 525.

Fig. 3. *Phalacroma turbineum* Kofoid and Michener, right lateral view; type specimen. Station 4681 (300–0 fathoms). × 1090.

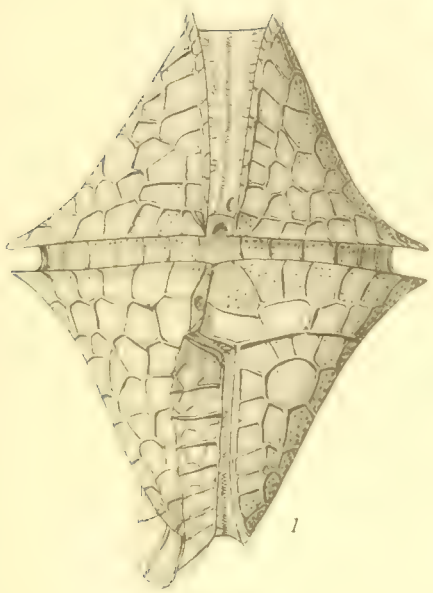
Fig. 4. *Phalacroma giganteum* Kofoid and Michener, structure of thecal wall near sagittal suture, which is serrated. Station 4699 (300–0 fathoms). × 1090.

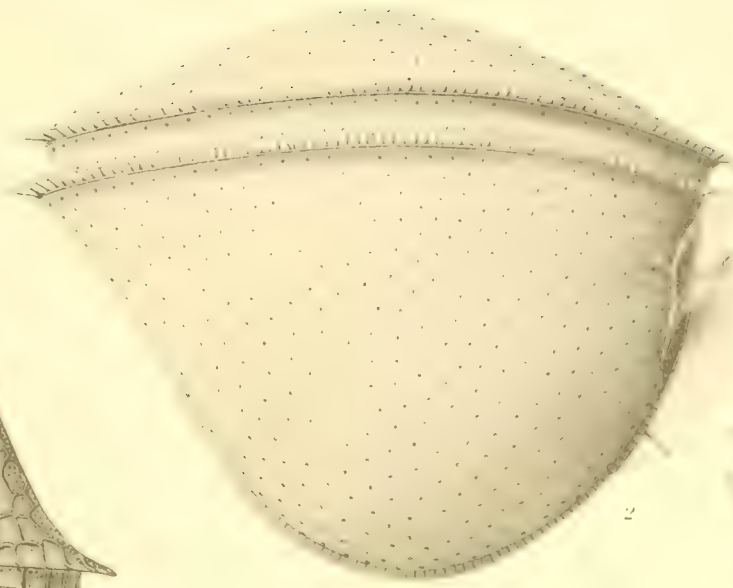
Fig. 5. *Phalacroma striatum* Kofoid, ventral view, somewhat tilted posteriorly; type specimen. Station 4705 (300–0 fathoms). × 700.

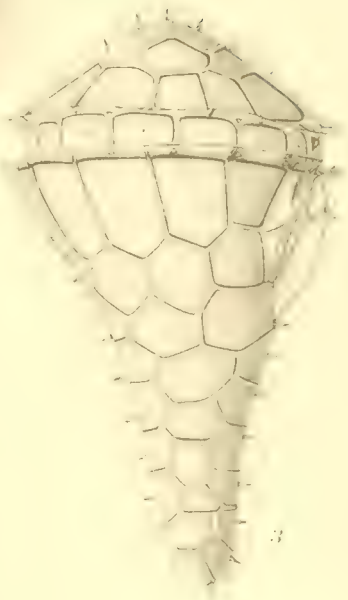
Fig. 6. *Phalacroma turbineum* Kofoid and Michener, protoplasmic contents, apparently shrunken, showing the large, round nucleus with moniliform chromatin and three nucleoli. Station 4715 (300–0 fathoms). × 525.

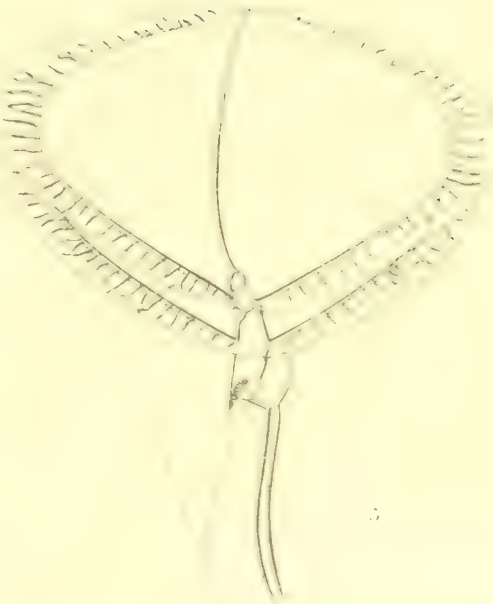
Fig. 7. *Phalacroma favus* Kofoid and Michener, right lateral view; type specimen. Station 4737 (300–0 fathoms). × 1090.

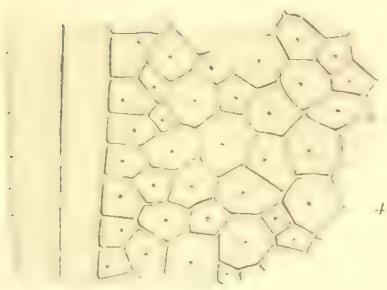
Fig. 8. *Phalacroma striatum* Kofoid, right lateral view; type specimen. Station 4705 (300–0 fathoms). × 700.











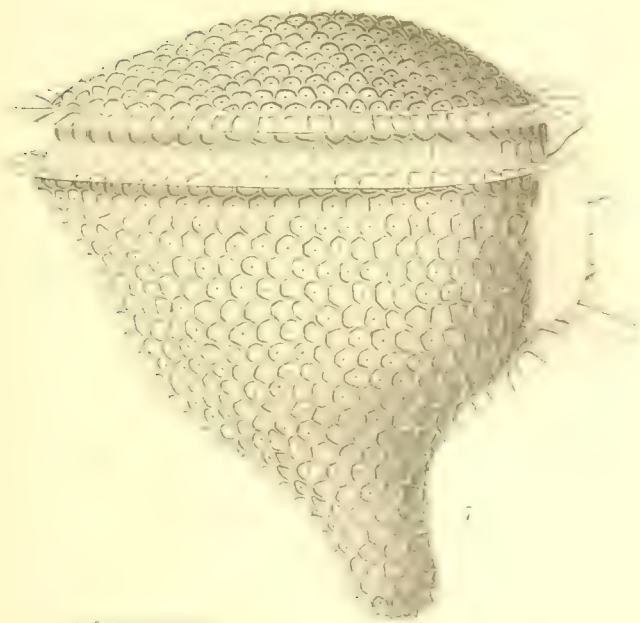


PLATE 3.

PLATE 3.

Fig. 1. *Phalacroma pulchrum* Kofoid and Michener, ventral view; type specimen. Station 4699 (300–0 fathoms). × 1090.

Fig. 2. *Phalacroma giganteum* Kofoid and Michener, seen from above. Station 4699 (300–0 fathoms). Note the two pores on ventral side of epitheca, near anterior cingular list (on upper side of figure). × 785.

Fig. 3. *Phalacroma limbatum* Kofoid and Michener, ventral view; type specimen. Station 4667 (300–0 fathoms). × 1090.

Fig. 4. *Phalacroma limbatum* Kofoid and Michener (?), right lateral view of specimen of uncertain allocation; parasagittal lists apparently not yet fully developed. Station 4687 (300–0 fathoms). × 1090.

Fig. 5. *Phalacroma limbatum* Kofoid and Michener, right lateral view; type specimen. Station 4667 (300–0 fathoms). × 925.

Fig. 6. *Phalacroma pulchrum* Kofoid and Michener, right lateral view; type specimen. Station 4699 (300–0 fathoms). × 1090.

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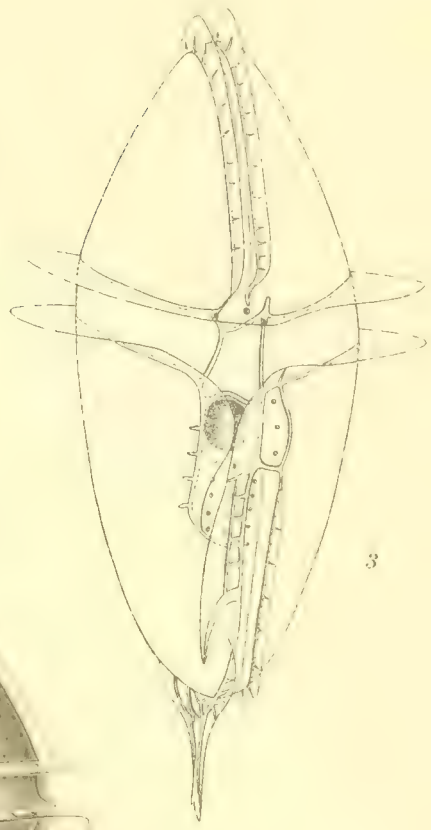

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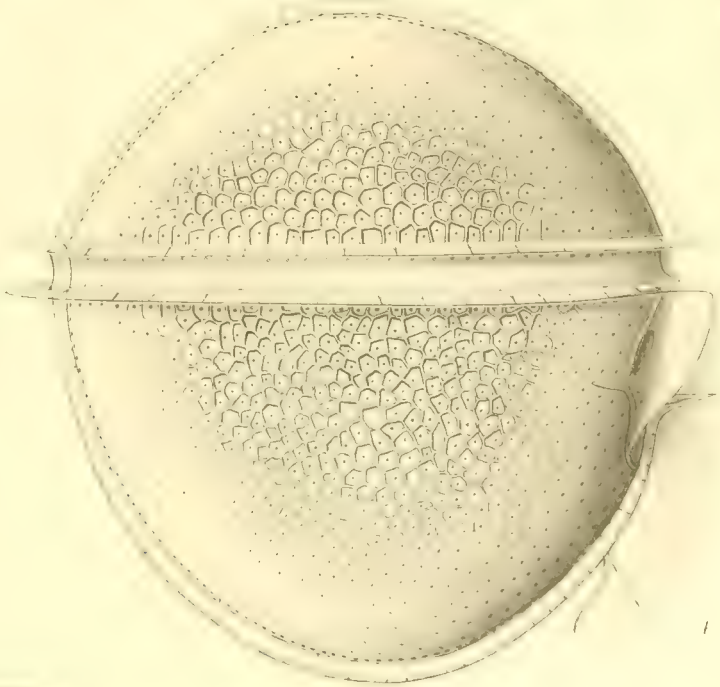

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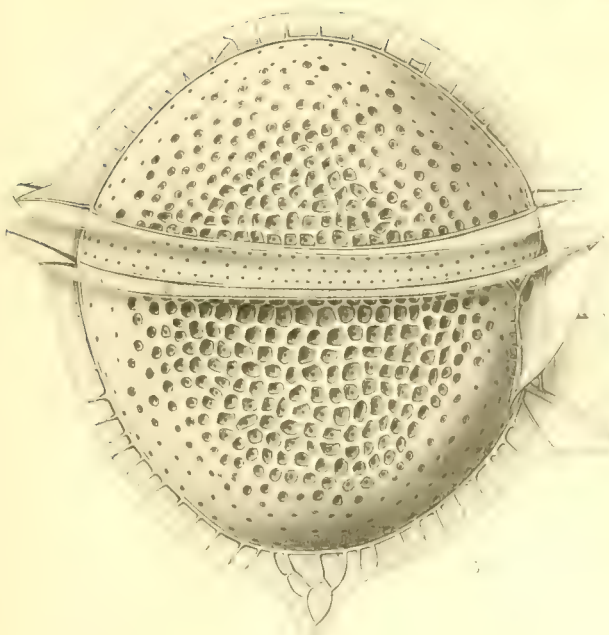

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PLATE 4.

PLATE 4.

Fig. 1. *Phalacroma turbineum* Kofoid and Michener, ventral view; type specimen. Station 4681 (300–0 fathoms). × 1090.

Fig. 2. The same, dorsal view, somewhat tilted to the left. × 1090.

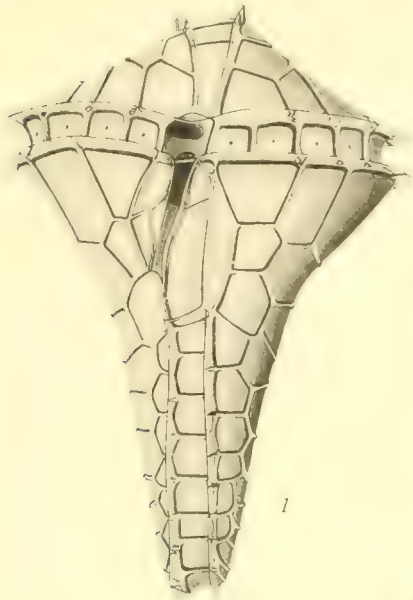
Fig. 3. *Phalacroma reticulatum* Kofoid, right lateral view, somewhat tilted ventrally; type specimen. Station 4740 (300–0 fathoms). × 525.

Fig. 4. *Phalacroma fimbriatum* Kofoid and Michener, right lateral view; type specimen. Station 4613 (300–0 fathoms). × 1090.

Fig. 5. *Phalacroma reticulatum* Kofoid, dorsal view; type specimen. Station 4740 (300–0 fathoms). × 525.

Fig. 6. *Phalacroma praetextum* Kofoid and Michener, right lateral view; type specimen. Station 4742 (300–0 fathoms). × 1090.

Fig. 7. The same, ventral view. Note the large cribriform plate, a unique feature in this genus. × 1090.



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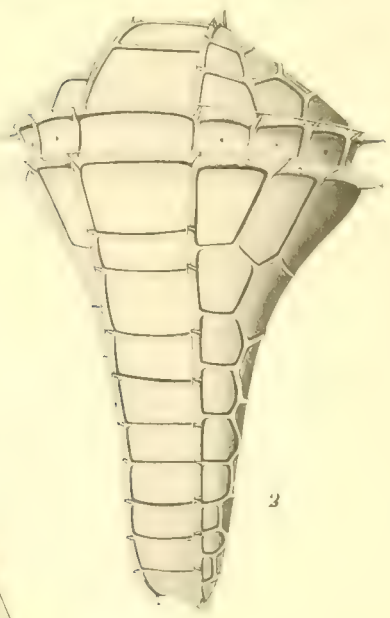

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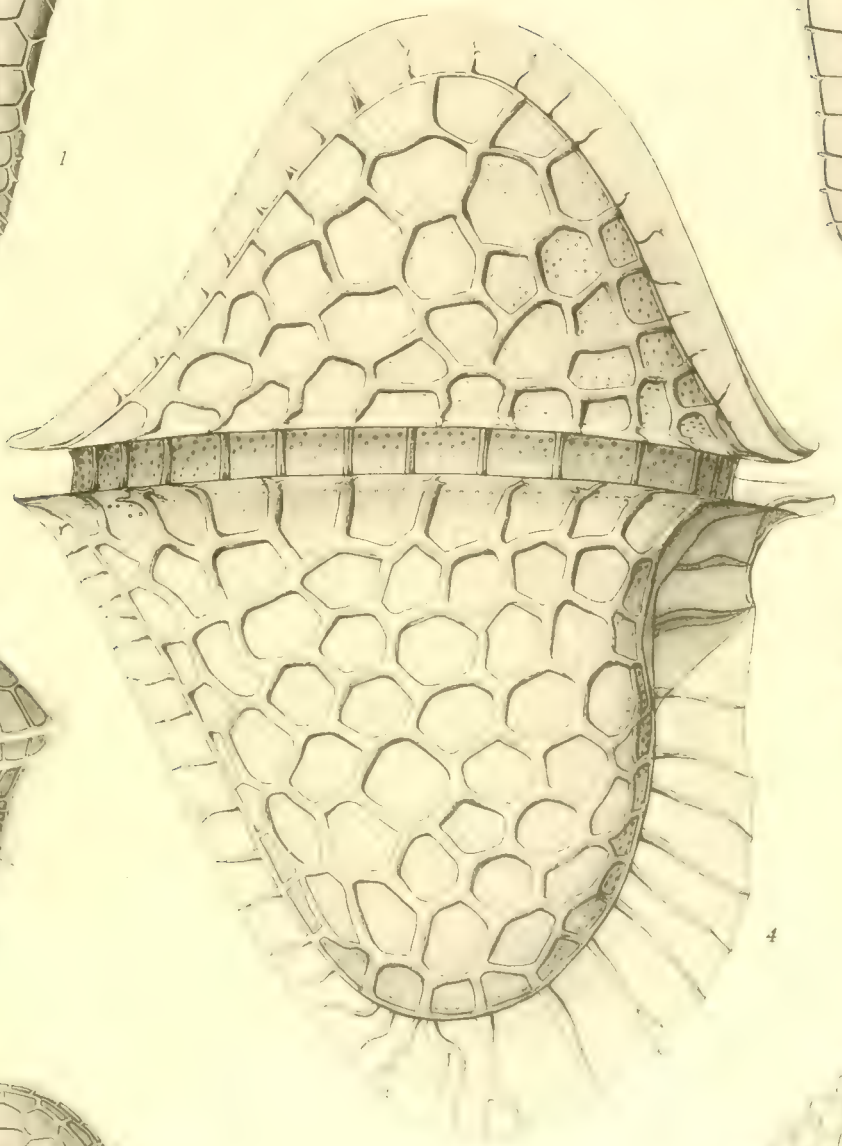

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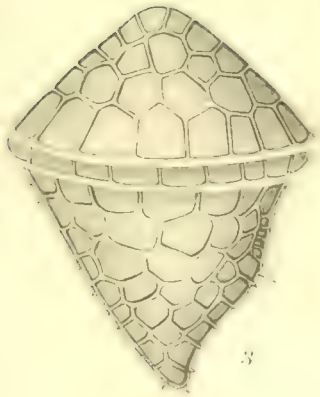

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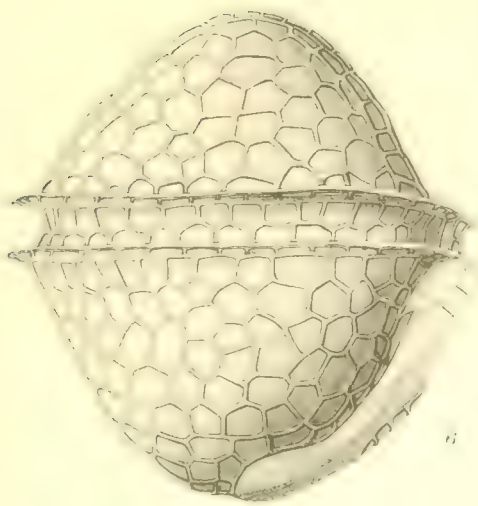

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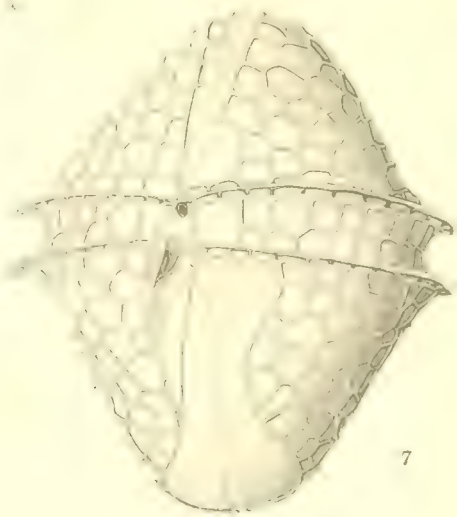

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PLATE 5.

PLATE 5.

Fig. 1. *Phalacroma expulsum* (Kofoid and Michener), right lateral view; type specimen. Station 4717 (300–0 fathoms). × 1090.

Fig. 2. *Dinophysis collaris* Kofoid and Michener, right lateral view; type specimen. Station 4671 (300–0 fathoms). × 665.

Fig. 3. *Dinophysis jörgenseni*, sp. nov., ventral view of type specimen, the two halves of which have broken apart, showing that the larger portion of the longitudinal furrow and the entire flagellar pore belong to the right valve and that the two members of the fission rib belong to different valves. The valves were separated by the pressure of the cover-glass. Station 4727 (surface). × 1090.

Fig. 4. *Dinofurcula ultima* (Kofoid), right lateral view; type specimen. Station 4711 (300–0 fathoms). × 1090.

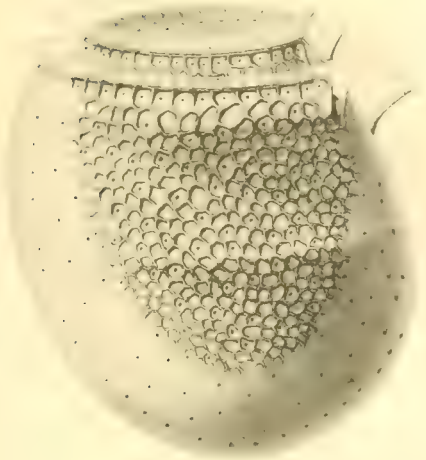
Fig. 5. *Histiophysis rugosa* (Kofoid and Michener), right lateral view; type specimen. Station 4705 (300–0 fathoms). × 1090.

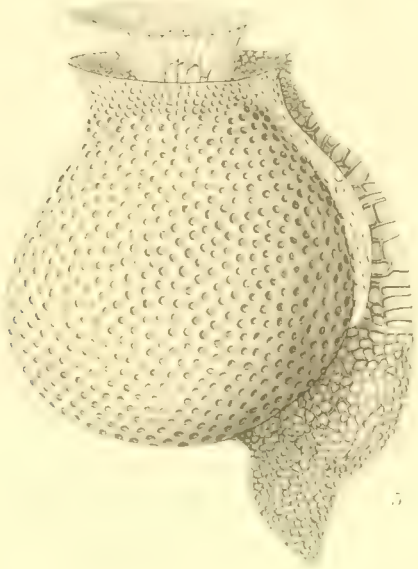
Fig. 6. *Dinofurcula ultima* (Kofoid), ventral view, showing that the two posterior processes do not lie in the same plane but form an angle of about 20°; type specimen. Station 4711 (300–0 fathoms). × 1090.

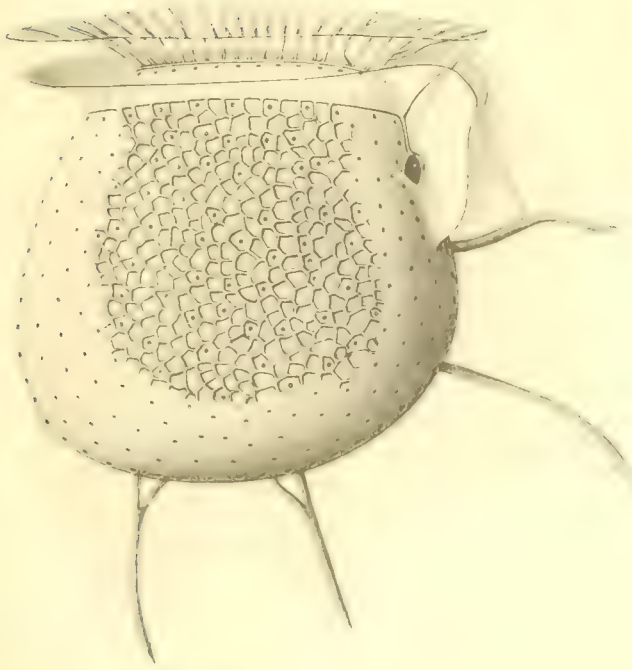
Fig. 7. *Dinophysis jörgenseni*, sp. nov., right lateral view; type specimen. Station 4727 (surface). × 1090.

Fig. 8. *Dinophysis collaris* Kofoid and Michener, ventral view; type specimen. Station 4671 (300–0 fathoms). × 665.

Fig. 9. *Dinophysis swezyi*, sp. nov., right lateral view; type specimen. La Jolla, California. × 975.







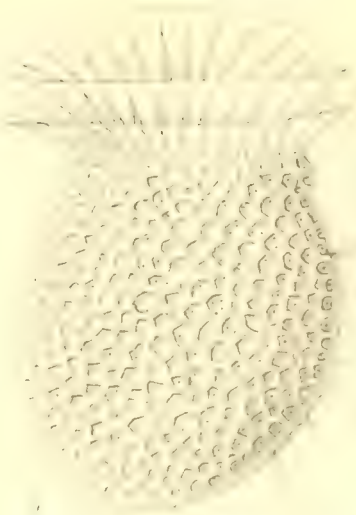


PLATE 6.

PLATE 6.

Fig. 1. *Amphisolenia brevicauda* Kofoid, right lateral view of anterior portion of body; type specimen. Station 4740 (300–0 fathoms). × 1100.

Fig. 2. *Amphisolenia inflata* Murray and Whitting, right lateral view of anterior portion of body showing structural differentiation of thecal wall, reticulation of right sulcal list, and peculiar differentiation of left sulcal list near flagellar pore. Station 4681 (300–0 fathoms). × 1100.

Fig. 3. *Amphisolenia extensa* Kofoid, right lateral view of anterior portion of body showing irregular ribs anteriorly on sulcal lists; type specimen. Station 4699 (300–0 fathoms). × 1100.

Fig. 4. *Amphisolenia brevicauda* Kofoid, dorsal view of posterior portion of body showing short antapical, not inflated posteriorly, and the pointed antapex lacking spinules; type specimen. Station 4740 (300–0 fathoms). × 1100.

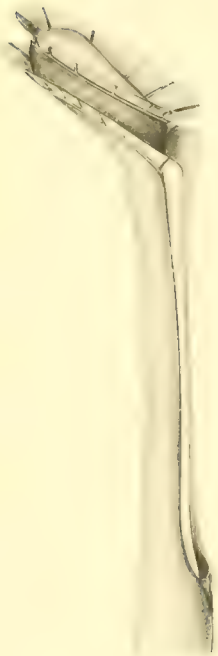
Fig. 5. *Amphisolenia extensa* Kofoid, dorsal view of the inflated, club-shaped, and subtruncate posterior portion of antapical lacking spinules; type specimen. Station 4699 (300–0 fathoms). × 2200.

Fig. 6. *Amphisolenia laticincta* Kofoid, lateral view of posterior portion of antapical showing the rounded but not inflated antapex with a minute spinule (in typical specimens probably one minute spinule on each valve); type specimen. Station 4740 (300–0 fathoms). × 2200.

Fig. 7. *Amphisolenia inflata* Murray and Whitting, right lateral view showing protoplasmic contents with rather large ovoidal nucleus, numerous small chromatophores, and metaplasmic inclusions. Station 4681 (300–0 fathoms). × 530.

Fig. 8. *Amphisolenia laticincta* Kofoid, right lateral view of anterior portion of body showing "accessory sulcal list" on left sulcal list; type specimen. Station 4740 (300–0 fathoms). × 2200.

Fig. 9. The same, lateral view of anterior process and midbody showing vacuolated protoplasm with large, oblong nucleus. × 1100.



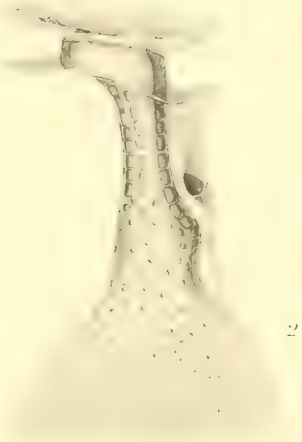


PLATE 7.

PLATE 7.

Amphisolenia schauinslandi Lemmermann. Station 4736 (300–0 fathoms).

Fig. 1. Right lateral view of anterior portion of body. × 1100.

Fig. 2. Right lateral view of middle portion of body showing protoplasmic contents somewhat shrunken away from thecal wall. Nucleus of moderate size, elongate, somewhat irregular, and with ventral depression, in which a centrosome (?) is located. Chromatophores are rod-shaped, moniliform, and longitudinal. In anterior portion of midbody there are irregular and filamentous rhabdosomes (?) and spirally arranged, segmented structures of unknown nature. In posterior portion of midbody segmented and irregularly arranged filaments and crystalline aggregations are seen. × 1100.

Fig. 3. Right lateral view of anterior portion of body showing thickness of thecal wall and flagellum. × 1100.

Fig. 4. Right lateral view. × 235.

Figs. 5, 6, 7. Posterior portion of antapical. Antapex is truncate and somewhat inflated, with four spinules arranged symmetrically, two on each valve, two dorsal and two ventral. Figure 5, in right lateral view, showing porulation; figure 6, in right lateral view, showing thickness of thecal wall; figure 7, in dorsoventral view. × 1100.

Fig. 8. Right lateral view of body with protoplasmic contents. × 235.

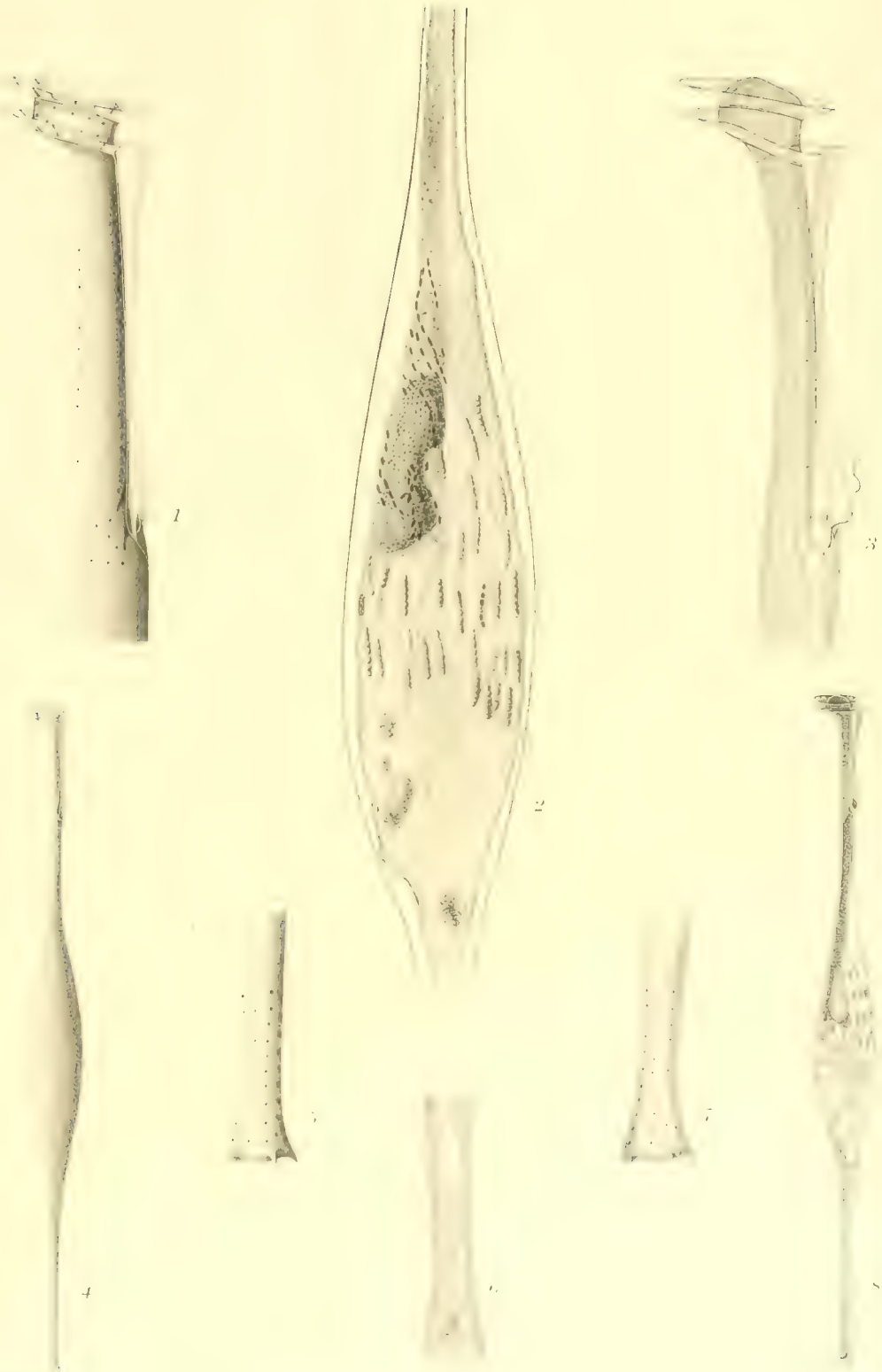

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PLATE 8.

PLATE 8.

Fig. 1. *Amphisolenia globifera* Stein, ventral view of posterior portion of antapical, showing terminal knob, neck-like constriction with protoplasmic sheath in front of knob, inflation in front of constriction, porulation, and two antapical spinules, one on each valve. Station 4613 (300–0 fathoms). × 2200.

Fig. 2. The same, right lateral view of anterior portion of body. × 1100.

Fig. 3. *Amphisolenia rectangulata* Kofoid, right lateral view of anterior portion of body; type specimen. Station 4740 (300–0 fathoms). × 1100.

Fig. 4. *Amphisolenia globifera* Stein, right lateral view of posterior portion of antapical of specimen represented by figure 1. × 2200.

Fig. 5. *Amphisolenia rectangulata* Kofoid, right lateral view of posterior portion of antapical showing slight inflation and porulation. Antapex is truncate with four spinules arranged symmetrically, two on each valve, two dorsal and two ventral; only the two spinules of right valve are visible; type specimen. Station 4740 (300–0 fathoms). × 2200.

Fig. 6. The same specimen, dorsal view of posterior portion of antapical showing bilateral compression. × 2200.

Fig. 7. The same specimen, right lateral view showing protoplasmic contents with large, elongate nucleus and pusule opening at flagellar pore. × 235.

Fig. 8. *Amphisolenia globifera* Stein, right lateral view of middle portion of protoplasmic body showing ovoidal nucleus of moderate size, pusule opening at flagellar pore, and several rather small, ovoidal chromatophores. Station 4613 (300–0 fathoms). × 530.

Fig. 9. *Amphisolenia rectangulata* Kofoid, sublateral view of posterior portion of antapical; type specimen. Station 4740 (300–0 fathoms). × 2200.

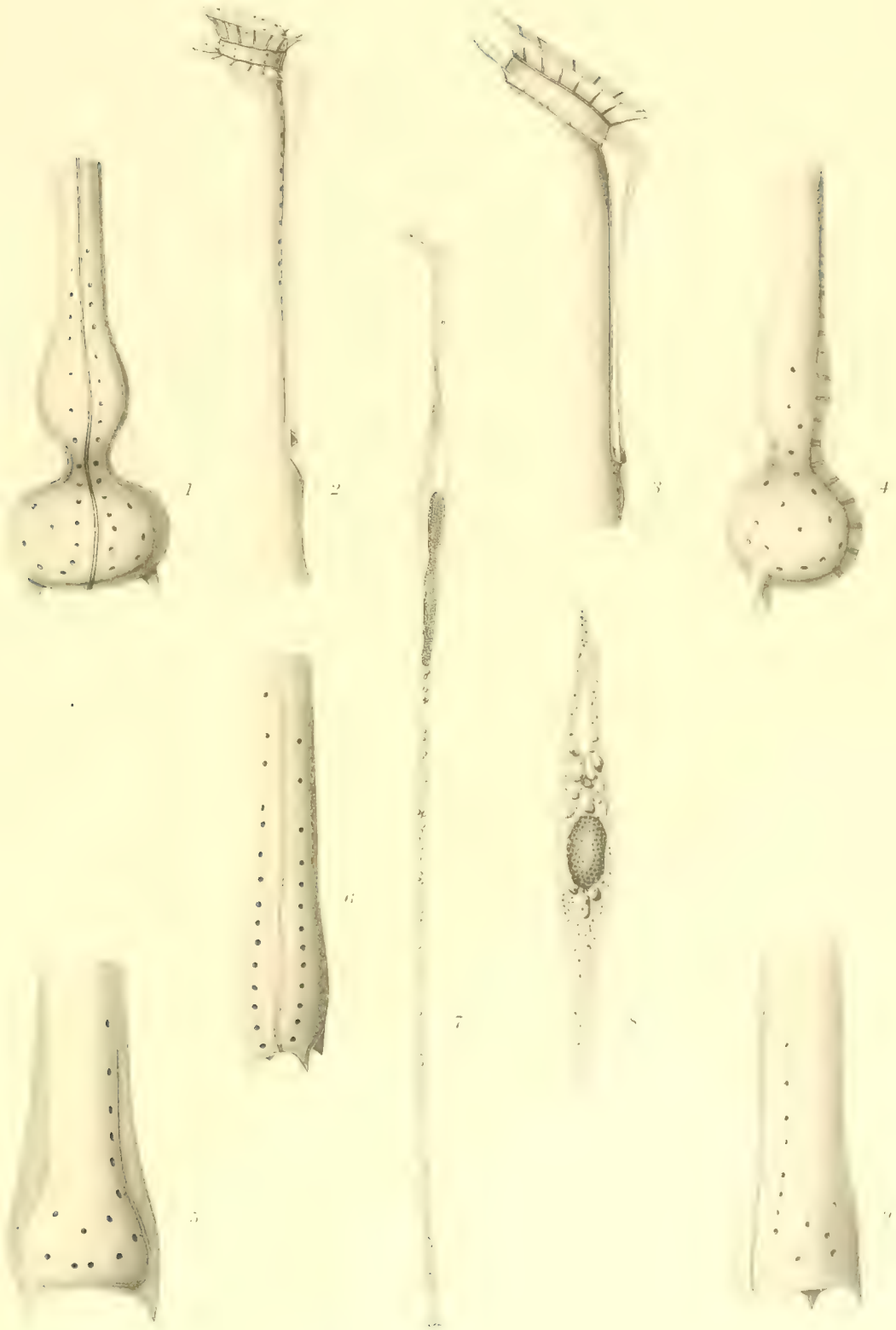
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PLATE 9.

PLATE 9.

Fig. 1. *Amphisolenia bispinosa* Kofoid, right lateral view of anterior portion of body showing longitudinal ridge on neck; type specimen. Station 4605 (300–0 fathoms). × 1100.

Fig. 2. *Amphisolenia quadrispina* Kofoid, ventral view of posterior portion of neck and anterior portion of anterior process showing flagellar pore, anterior portion of efferent duct of pusule, and cytopharyngeal depression; type specimen. Station 4711 (300–0 fathoms). × 785.

Fig. 3. The same specimen, ventral view of anterior portion of body in front of portion shown in figure 2. × 785.

Fig. 4. The same specimen, lateral view of posterior portion of antapical showing terminal knob, neck-like constriction in front of knob, inflation in front of constriction, porulation, and four antapical spinules placed symmetrically on the two valves. × 785.

Fig. 5. *Amphisolenia curvata* Kofoid, right lateral view of anterior portion of body showing longitudinal ridge on neck and "accessory sulcal list" on left sulcal list; type specimen. Station 4605 (300–0 fathoms). × 1100.

Fig. 6. *Amphisolenia bispinosa* Kofoid, lateral view of middle portion of body showing protoplasmic contents with rather large, elongate, irregular nucleus and, anteriorly and posteriorly, some small rounded or ovoidal chromatophores; type specimen. Station 4605 (300–0 fathoms). × 530.

Fig. 7. The same specimen, dorsal view of posterior portion of antapical showing the truncate antapex with two long lateral spinules, one on right and one on left valve, and porulation. × 1100.

Fig. 8. The same specimen, right lateral view of posterior portion of antapical showing slight inflation and rounded antapex. × 1100.

Fig. 9. *Amphisolenia curvata* Kofoid, ventral view of posterior portion of antapical showing short, strong antapical spinule on left valve, irregular ridges, and porulation; in typical specimens probably one spinule on each valve; type specimen. Station 4605 (300–0 fathoms). × 1100.

Fig. 10. The same specimen, right lateral view of posterior portion of antapical showing slight inflation and rounded antapex. × 1100.

Fig. 11. *Amphisolenia lemmermanni* Kofoid, right lateral view of posterior portion of antapical of atypic specimen showing abrupt expansion of posterior end, truncate antapex with only one spinule, and protoplasmic sheath in front of expanded posterior end. Station 4734 (300–0 fathoms). × 1060.

Fig. 12. The same, right lateral view of posterior portion of antapical of type specimen showing abrupt expansion of porulose posterior end and in front of this expansion slight inflation and protoplasmic sheath; antapex is truncate with two rather strong sagittal spinules, both belonging to left valve. Station 4730 (300–0 fathoms). × 1400.

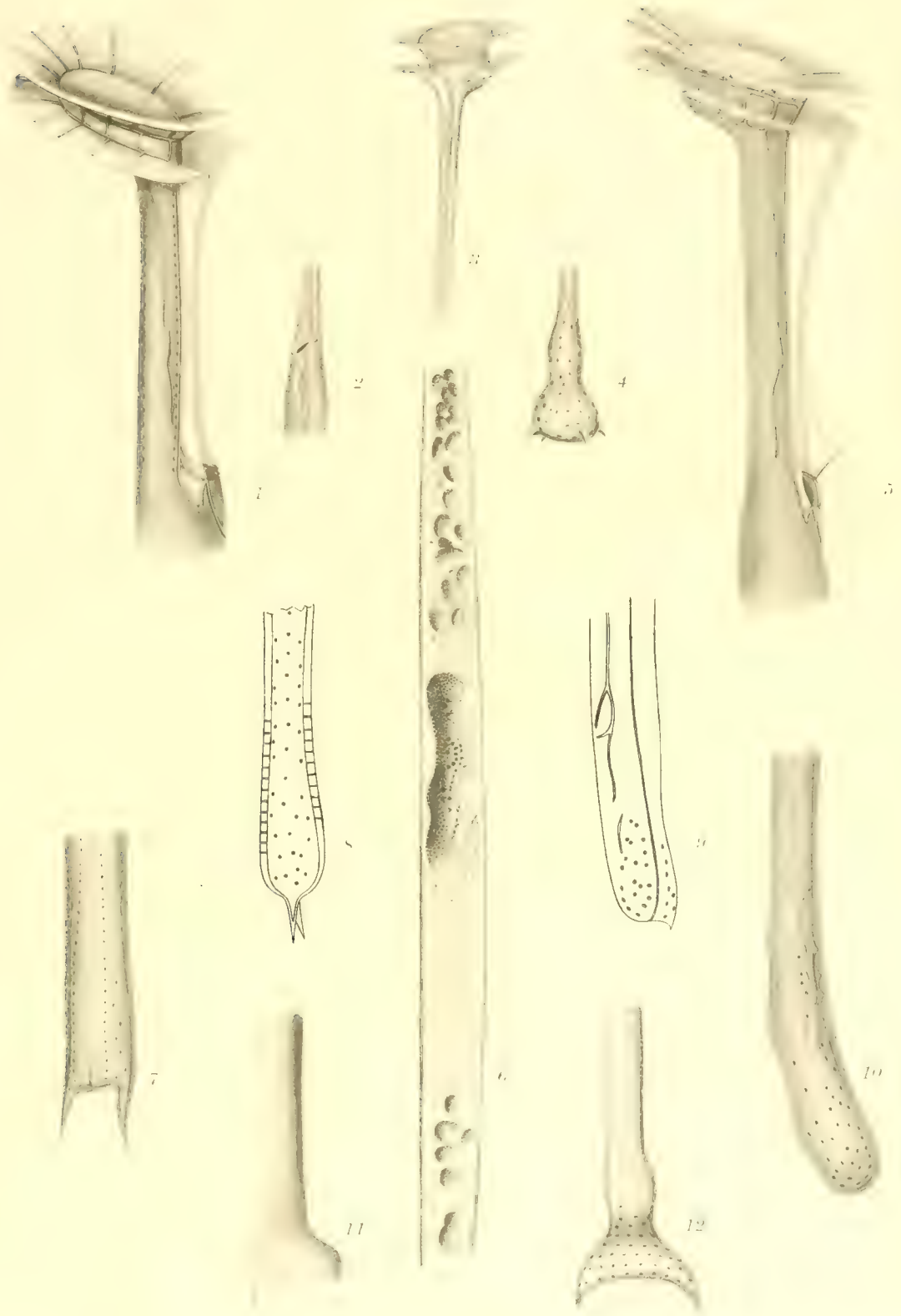
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PLATE 10.

PLATE 10.

Fig. 1. *Amphisolenia astragalus* Kofoid, right lateral view of anterior portion of body showing longitudinal ridge on neck and longitudinal rib on right sulcal list; type specimen. Station 4713 (300–0 fathoms). × 1100.

Fig. 2. *Amphisolenia schröderi* Kofoid, right lateral view of posterior portion of antapical; type specimen. Station 4737 (300–0 fathoms). × 1100.

Fig. 3. The same specimen, right lateral view of anterior portion of body. × 1100.

Fig. 4. The same specimen, ventral view of posterior portion of antapical showing slight inflation, porulation, and, on antapex, two small sagittal spinules both probably belonging to left valve. × 1100.

Fig. 5. *Amphisolenia complanata*, sp. nov., right lateral view of anterior portion of body. Station 4739 (300–0 fathoms). × 1100.

Fig. 6. *Amphisolenia astragalus* Kofoid, right lateral view of posterior foot-like portion of antapical showing porulation, rounded heel without any "heel-spinule," the rather strong, pointed spinule on antapex, and the rounded, wart-like protuberance somewhat in front of antapex; type specimen. Station 4713 (300–0 fathoms). × 2200.

Fig. 7. *Amphisolenia complanata*, sp. nov., dorsal view of posterior portion of antapical showing slight inflation, porulation, and, on antapex, two rather strong sagittal spinules both probably belonging to left valve. Station 4739 (300–0 fathoms). × 1100.

Fig. 8. *Amphisolenia astragalus* Kofoid, right lateral view of midbody showing protoplasmic contents with rather large, elongate nucleus, some rather small, rounded or ovoidal chromatophores, and metaplasmic inclusions; type specimen. Station 4713 (300–0 fathoms). × 530.

Fig. 9. *Amphisolenia complanata*, sp. nov., right lateral view of posterior portion of antapical of specimen represented by figure 7 showing very slight inflation. Station 4737 (300–0 fathoms). × 1100.

Fig. 10. *Amphisolenia astragalus* Kofoid, ventral view of posterior portion of antapical; type specimen. Station 4713 (300–0 fathoms). × 2200.

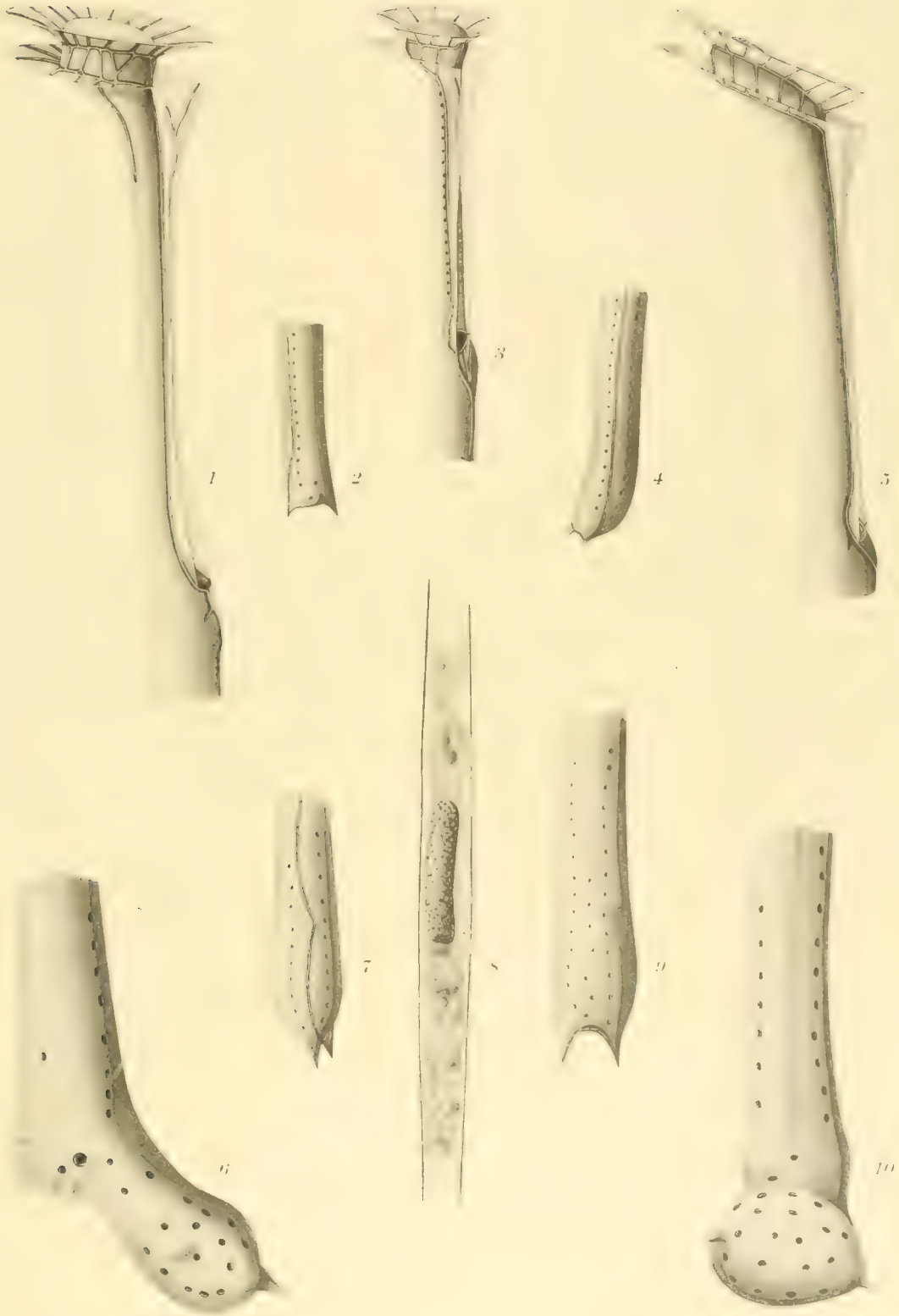

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PLATE 11

PLATE 11.

Fig. 1. *Amphisolenia truncata* Kofoid and Michener, right lateral view of anterior portion of body; right sulcal list omitted; type specimen. Station 4733 (surface). × 1100.

Fig. 2. *Amphisolenia palaeotheroides* Kofoid, dorsal view of porulose posterior portion of antapical. Distal end foot-like and bent to the right. Foot-like portion about twice as long as wide. Left valve with three strong spinules: one, the "heel-spinule," placed at point of bending, the two others distal. Right valve with one spinule only which is placed between the distal spinules of left valve, and about as strong as or somewhat stronger than distal spinules of left valve; type specimen. Station 4732 (300–0 fathoms). × 1100.

Fig. 3. The same specimen, right sublateral view of posterior portion of antapical showing inflation. × 1100.

Fig. 4. The same specimen, right lateral view of anterior portion of body. Left sulcal list with fission rib. With numerous pores. × 1100.

Fig. 5. *Amphisolenia asymmetrica* Kofoid, right lateral view of posterior portion of antapical of type specimen showing inflation. Station 4732 (300–0 fathoms). × 1100.

Fig. 6. *Amphisolenia asymmetrica* Kofoid, ventral view of anterior portion of body of specimen described by Kofoid (1907a) as *A. dolichocephalica*. Cingular lists not yet developed following binary fission. Station 4728 (300–0 fathoms). × 530.

Fig. 7. *Amphisolenia asymmetrica* Kofoid, posterior portion of antapical of type specimen in dorsal view. It differs from *A. palaeotheroides* (fig. 2) mainly in having the foot-like portion about seven to eight times longer than wide. Station 4732 (300–0 fathoms). × 1100.

Fig. 8. *Amphisolenia clavipes* Kofoid, right lateral view of anterior portion of body, with distal portion of efferent canal of pusule; type specimen. Station 4736 (300–0 fathoms). × 1100.

Fig. 9. The same specimen, left lateral view of posterior portion of antapical. Distal end somewhat inflated and gently curved toward the ventral side. Antapex is truncate, with two rather small sagittal spinules, one dorsal and one ventral, both probably belonging to left valve. × 1100.

Fig. 10. The same specimen, ventral view of posterior portion of antapical. Distal end strongly bent to the right; with rounded antapex. × 1100.

Fig. 11. The same specimen, lateral view of the middle portion of body showing protoplasmic contents. Behind the rather large, elongate nucleus some rod-shaped chromatophores are seen. × 1100.

Fig. 12. *Amphisolenia truncata* Kofoid and Michener, lateral view of posterior portion of body; antapex truncate, not inflated, and without spinules; type specimen. Station 4733 (surface). × 1100.

Fig. 13. *Amphisolenia asymmetrica* Kofoid, right lateral view of anterior portion of type specimen showing the extremely elongated head. Station 4732 (300–0 fathoms). × 530.

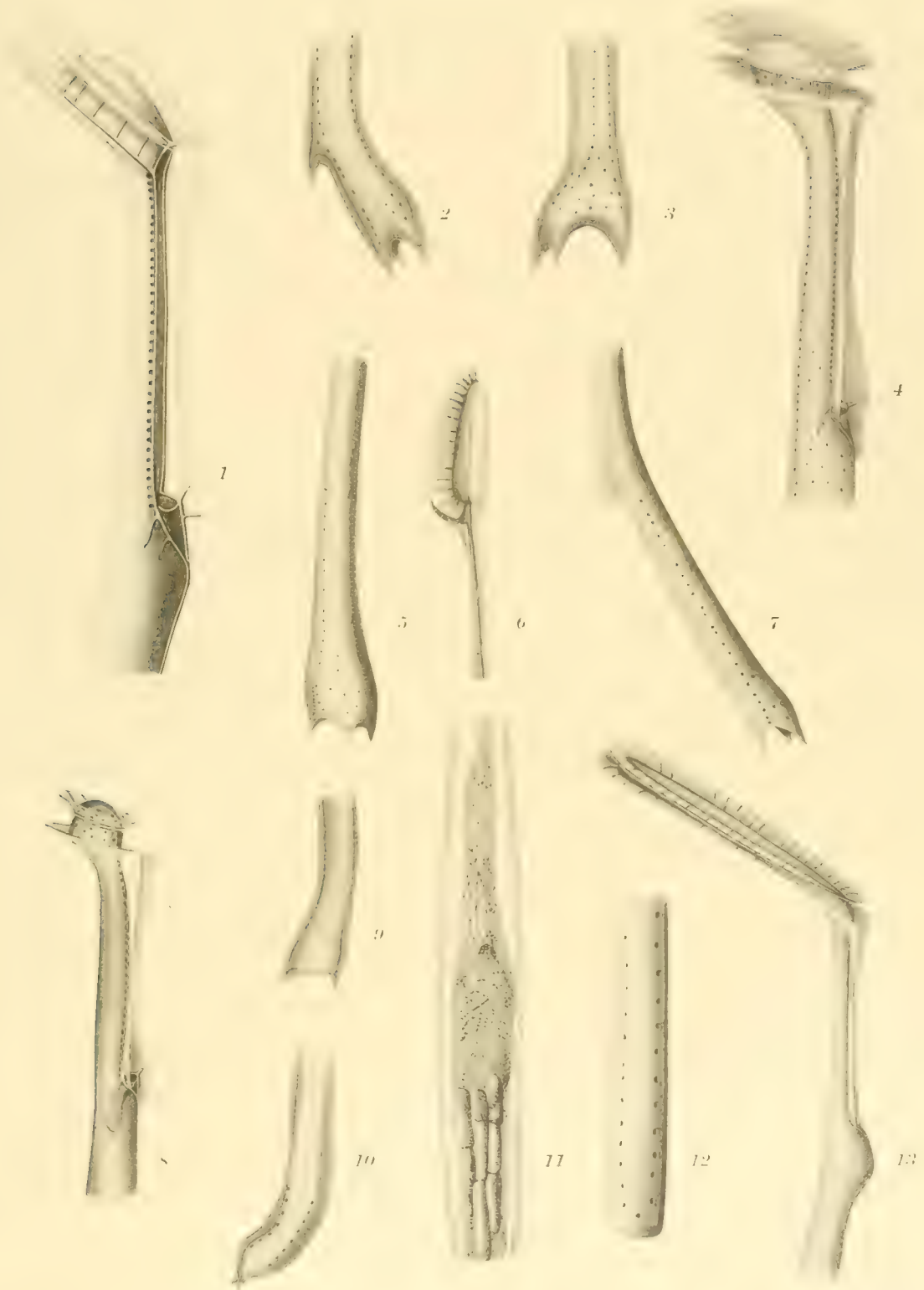
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PLATE 12.

PLATE 12.

Fig. 1. *Amphisolenia bifurcata* Murray and Whitting, subventral view of posterior portion of body showing bilateral compression and porulation. Distal end of both antapical stem and antapical branch has the same structure as distal end of antapical in *A. palmata;* see explanation of figure 7. Distal spinules of left valve unintentionally omitted. Station 4699 (300–0 fathoms). × 530.

Fig. 2. *Amphisolenia thrinax* Schütt, lateral view of midbody and anterior portion of antapical showing protoplasmic contents with large dumbbell-shaped nucleus, fairly numerous large, ovoidal or spheroidal chromatophores, and numerous groups of three to five very small, spheroidal bodies of unknown nature. In anterior portion of midbody a pusule is seen. Shape of nucleus probably indicates approaching division. Station 4732 (300–0 fathoms). × 530.

Fig. 3. *Amphisolenia bifurcata* Murray and Whitting, lateral view of posterior portion of body. Station 4699 (300–0 fathoms). × 530.

Fig. 4. *Amphisolenia palmata* Stein, right lateral view of posterior portion of antapical showing inflation, porulation, and three strong distal spinules. Station 4737 (300–0 fathoms). × 2200.

Fig. 5. *Amphisolenia bifurcata* Murray and Whitting, left lateral view of middle portion of body showing protoplasmic contents with ovoidal nucelus, many spheroidal metaplasmic inclusions of various sizes, and anterior portion of efferent canal of pusule. Station 4699 (300–0 fathoms). × 530.

Fig. 6. *Amphisolenia thrinax* Schütt, right lateral view of atypic specimen with antapical stem in front of first antapical branch very short, and with antapical stem behind second branch very inflated and of about the same shape and size as midbody and anterior process. Station 4594 (300–0 fathoms). × 120.

Fig. 7. *Amphisolenia palmata* Stein, ventral view of porulose posterior portion of antapical. Distal end is foot-like and bent to the right. Foot-like portion is two to three times longer than wide. Left valve has three strong spinules: one, the "heel-spinule," placed at point of bending, the two others distal. Right valve has one spinule only which is placed between and sometimes larger than distal spinules of left valve. Station 4737 (300–0 fathoms). × 220.

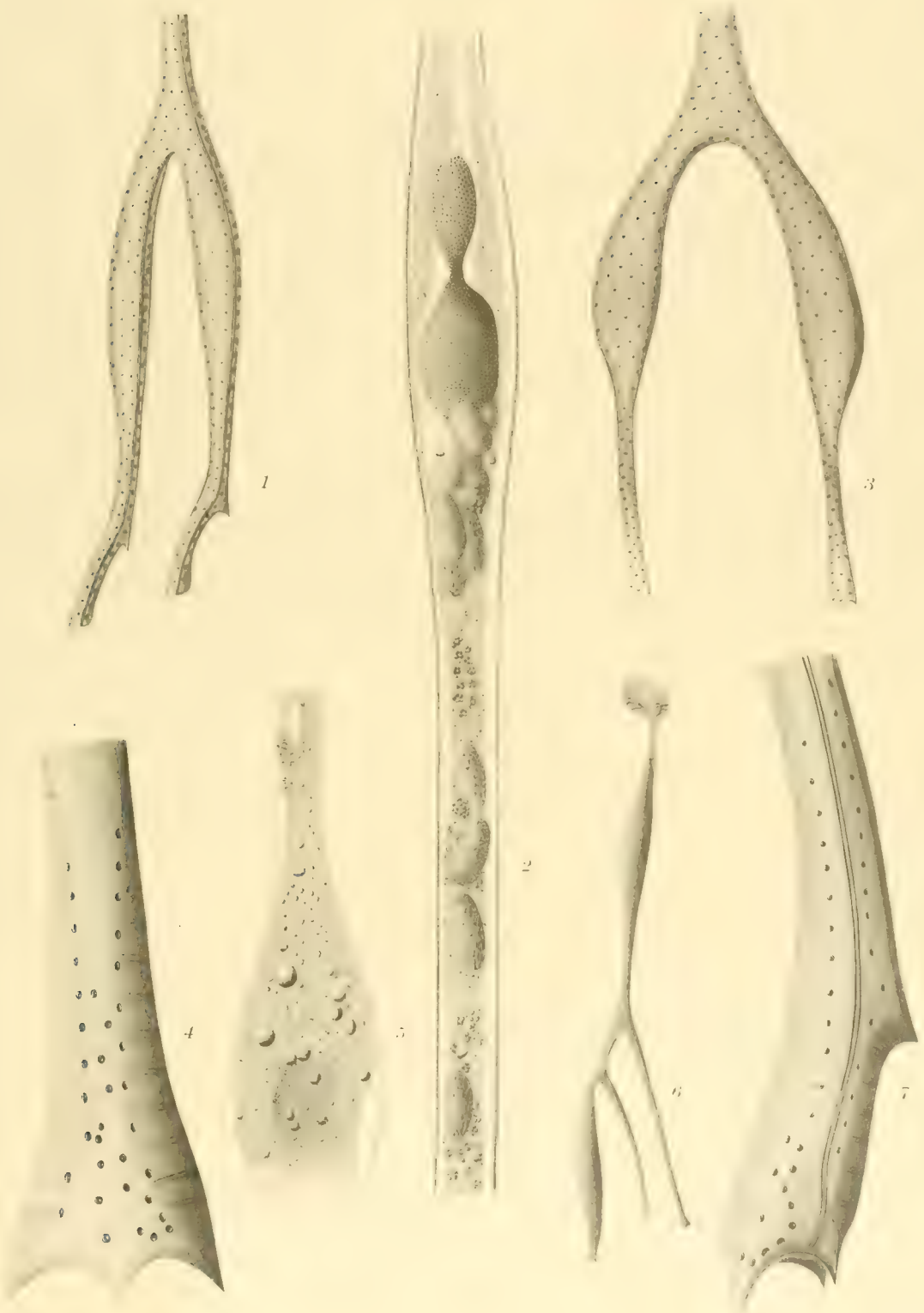
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PLATE 13.

PLATE 13.

Fig. 1. *Amphisolenia quadricauda* Kofoid, ventral view of anterior portion of right valve showing that the line of fission runs along middle of head, along left side of sulcus, crossing left sulcal list at fission rib, which is seen just in front of flagellar pore, to the left of flagellar pore and cytopharyngeal depression, and along the middle of anterior process; type specimen. Station 4695 (300–0 fathoms). × 1100.

Fig. 2. The same specimen, left valve of posterior portion of antapical stem seen from within showing elongate inner opening of cavity of "heel-spinule," cross-ridge near antapex, and porulation. × 1100.

Fig. 2a-d. Four optical cross-sections of thecal wall of portion represented by figure 2 at places corresponding to positions of the four figures, showing shape and thickness of thecal wall. × 1100.

Fig. 3–5. The same specimen, distal portions of left valve of third, second, and first antapical branches, respectively, seen from within showing that the first branch (fig. 5) has "heel-spinule" and is porulate, while the second and third branches lack "heel-spinule" and porulation. × 1100.

Fig. 6. The same specimen, right lateral view of anterior portion of right valve showing the part of left sulcal list, behind fission rib, that belongs to right valve. × 800.

Fig. 7. *Amphisolenia quinquecauda* Kofoid, somewhat twisted; anterior portion seen in ventral view, posterior in right lateral view; type specimen. Station 4739 (300–0 fathoms). × 120.

Fig. 8. *Amphisolenia quadricauda* Kofoid, left lateral view of anterior portion of left valve showing the part of left sulcal list, in front of fission rib, that belongs to left valve, ribs of the cingular and sulcal lists, and ridges and porulation of thecal wall; type specimen. Station 4695 (300–0 fathoms). × 825.

Fig. 9–13. *Amphisolenia quinquecauda* Kofoid, distal portion of antapical stem and of fourth, third, second, and first antapical branches. Antapical stem (fig. 9) and first antapical branch (fig. 13) are porulose and of *palmata* type (Pl. **12**, fig. 7) with long and slender "foot." Second, third, and fourth antapical branches (figs. 12, 11, 10) lack "heel-spinule" and porulation; type specimen. Station 4739 (300–0 fathoms). × 1100.

Fig. 14. The same specimen, right lateral view of anterior portion of body showing structural differentiation of lists and porulation of thecal wall, anterior portion of efferent canal of pusule, protoplasm of anterior process, and cytopharyngeal depression. × 1100.

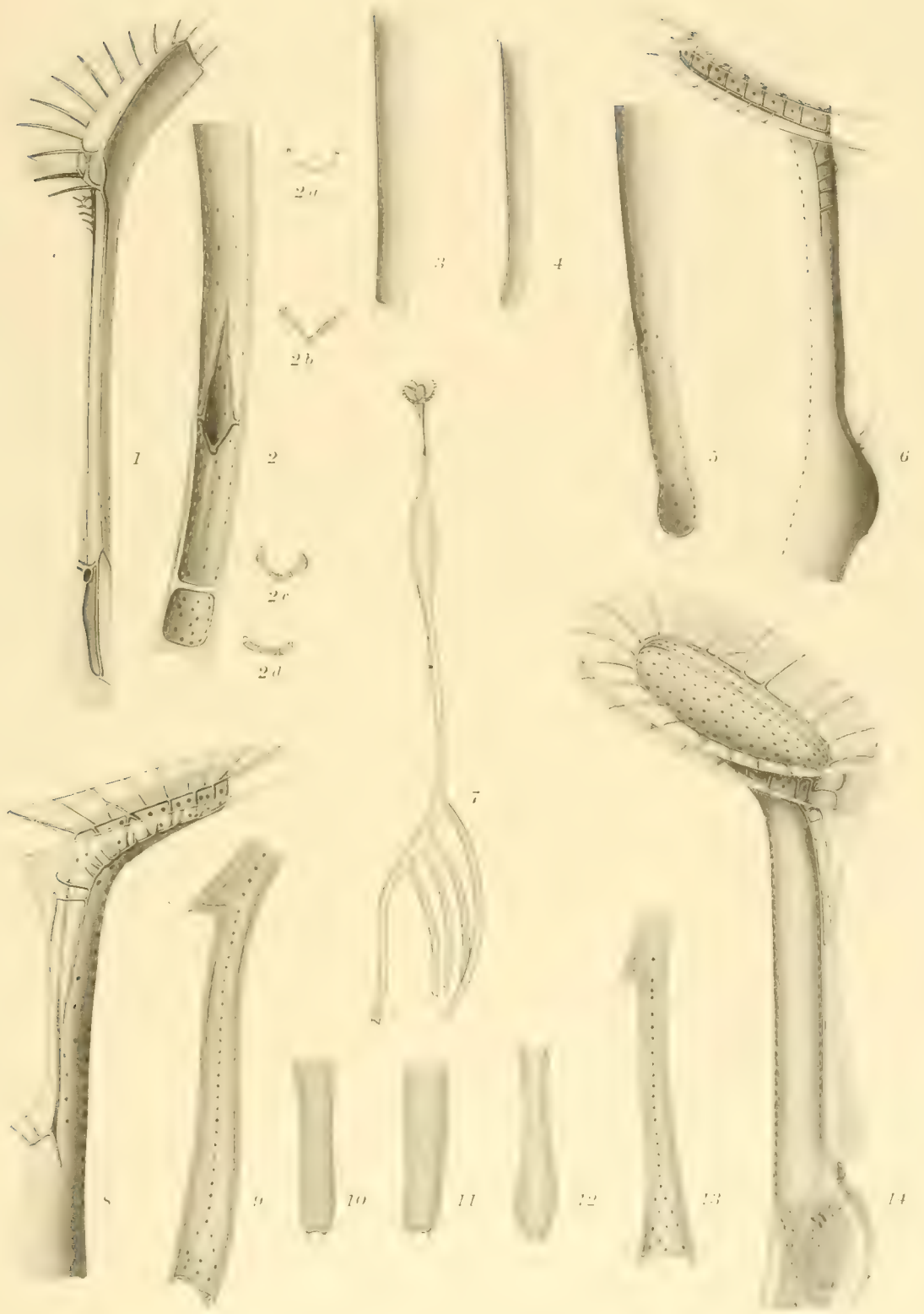
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PLATE 14.

PLATE 14.

Triposolenia truncata Kofoid.

Fig. 1. Right lateral view of anterior portion of body showing surface differentiation of thecal wall. Of the three ribs of left sulcal list, the anterior is the fission rib. Station 4742 (300–0 fathoms). × 1100.

Figs. 2, 3. Right lateral view of posterior portions of dorsal and ventral antapicals of specimen represented by figure 1. × 1100.

Triposolenia depressa Kofoid.

Fig. 4. Right lateral view. Station 4580 (300–0 fathoms). × 530.

Fig. 5. Right lateral view showing protoplasmic contents with large ovoidal nucleus and pusule opening at flagellar pore. Station 4580 (300–0 fathoms). × 530.

Fig. 6. Right lateral view of anterior portion of body. Station 4580 (300–0 fathoms). × 1100.

Figs. 7, 8. Right lateral view of posterior portions of dorsal and ventral antapicals showing thickness of thecal wall. Station 4580 (300–0 fathoms). × 1100.

Fig. 9. Dorsoventral view of body. Station 4580 (300–0 fathoms). × 550.

Triposolenia intermedia, sp. nov.

Fig. 10. Left lateral view of type specimen showing fine striation of thecal wall. Station 4580 (300–0 fathoms). × 530.

Triposolenia ambulatrix Kofoid.

Fig. 11. Right lateral view of type specimen. Station 4711 (300–0 fathoms). × 530.

Fig. 12. Right lateral view showing protoplasmic contents with large rounded nucleus, many rounded or ovoidal, highly refractive bodies, and distal end of efferent canal of pusule. Station 4711 (300–0 fathoms). × 530.

Fig. 13. Dorsoventral view of body. Station 4711 (300–0 fathoms). × 530.

Fig. 14. Right lateral view of anterior portion of body. Station 4711 (300–0 fathoms). × 1100.

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PLATE 15.

PLATE 15.

Triposolenia longicornis Kofoid.

Fig. 1. Right lateral view. Station 4583 (300–0 fathoms). × 530.

Fig. 2. Right lateral view showing protoplasmic contents with large rounded nucleus and pusule opening at flagellar pore. Station 4583 (300–0 fathoms). × 530.

Fig. 3. Dorsoventral view of body. Station 4583 (300–0 fathoms). × 530.

Fig. 4. Right lateral view of anterior portion of body. Station 4583 (300–0 fathoms). × 1100.

Figs. 5, 6. Right lateral view of posterior portions of dorsal and ventral antapicals showing thickness of thecal wall. Station 4583 (300–0 fathoms). × 1100.

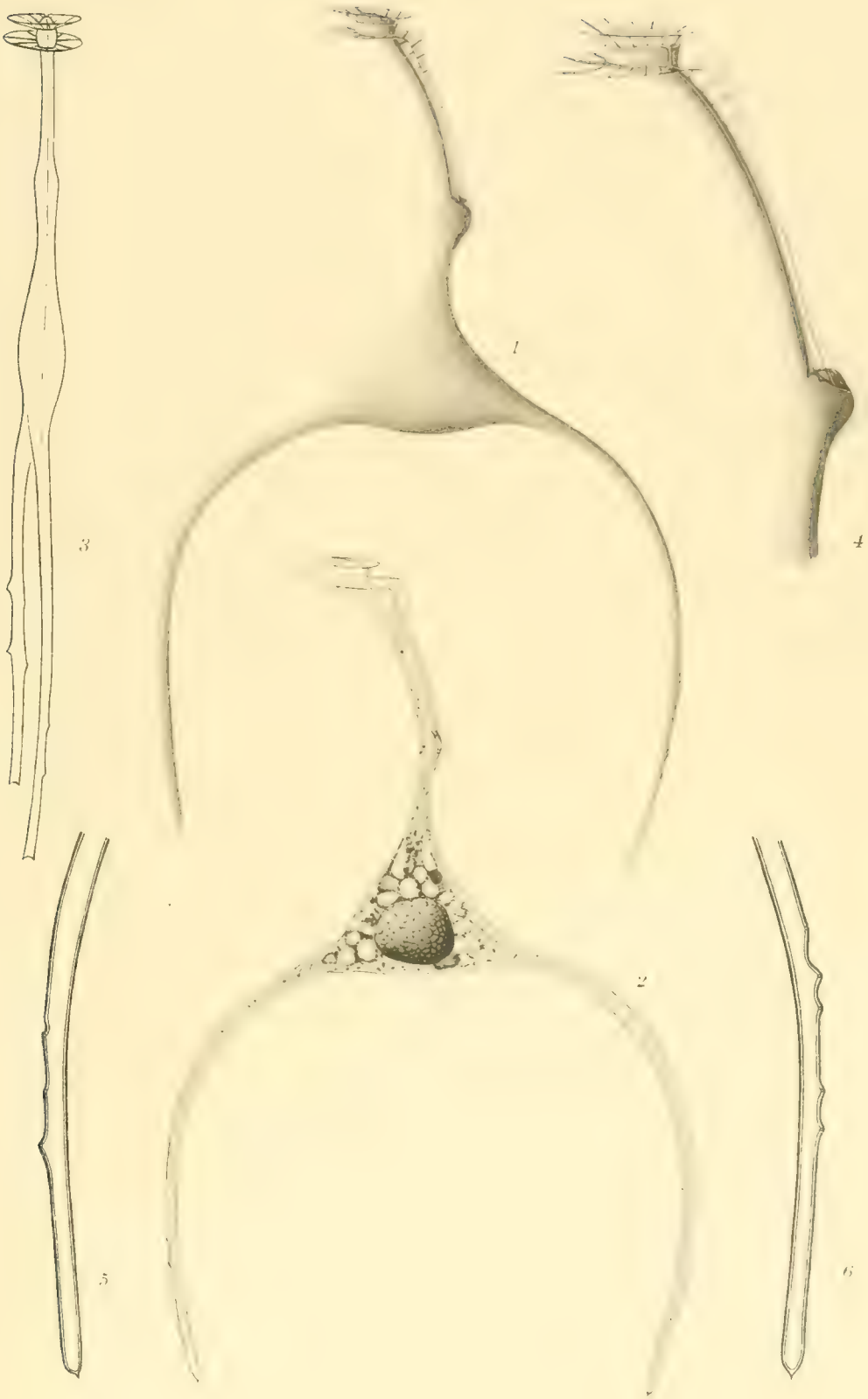

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PLATE 16.

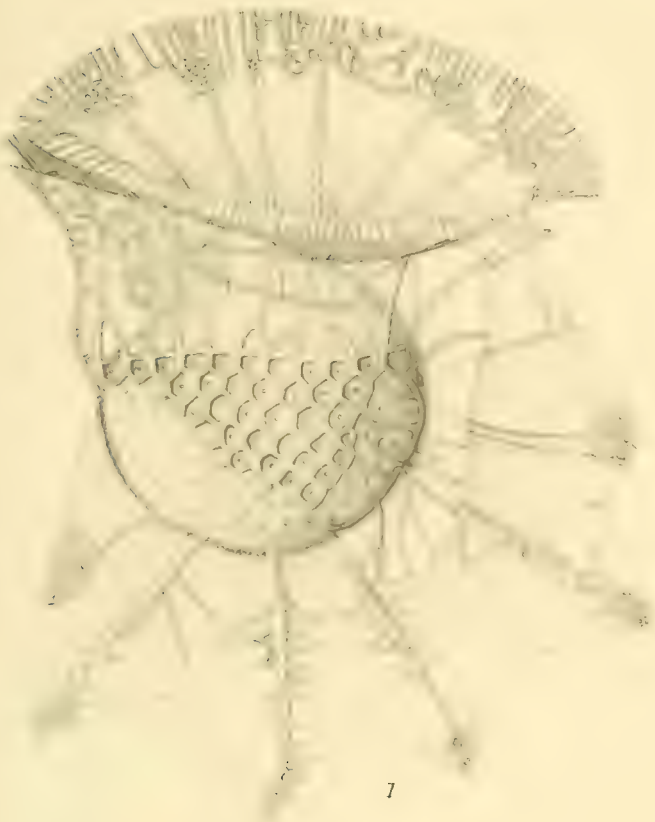
PLATE 16.

Fig. 1. *Ornithocercus steini* Schütt, *s. str.*, right lateral view. Under the pressure of the cover-glass, the anterior cingular list has split dorsally and ventrally and the posterior cingular list dorsally. La Jolla, California. × 625.

Fig. 2. *Ornithocercus splendidus* Schütt, seen from above, showing the structural differentiation of the anterior cingular list (structure of theca omitted). The sinuation on the left side of the figure is on the ventral side of the organism. La Jolla, California. × 975.

Fig. 3. *Ornithocercus magnificus* Stein, *s. str.*, right lateral view. La Jolla, California. × 975.

Fig. 4. *Ornithocercus splendidus* Schütt, right lateral view. La Jolla, California. × 975.



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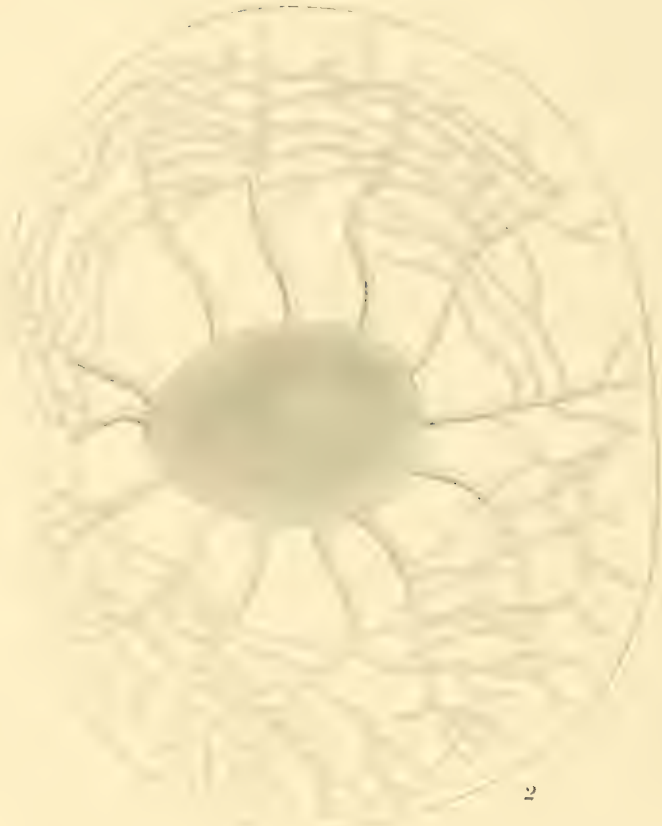

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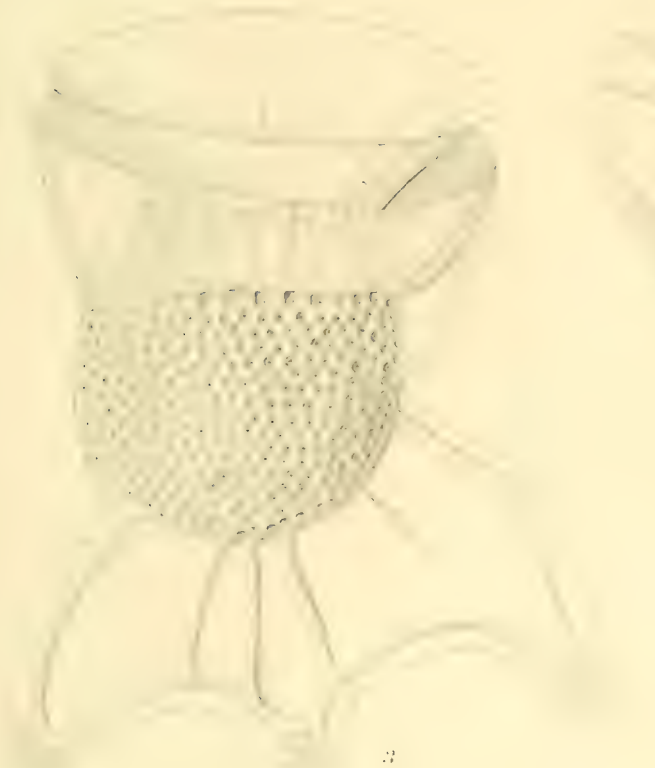

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PLATE 17.

PLATE 17.

Fig. 1. *Ornithocercus carolinae* Kofoid, right lateral view; type specimen. Station 4730 (300–0 fathoms). × 695.

Fig. 2. *Ornithocercus quadratus* Schütt, f. *simplex*, nov., right lateral view; type specimen. Station 4681 (300–0 fathoms). × 525.

Fig. 3. *Ornithocercus splendidus* Schütt, right lateral view. From the material of the Expedition; station unknown. × 525.

Fig. 4. *Ornithocercus formosus* Kofoid and Michener, ventral view; type specimen. Station 4697 (300–0 fathoms). × 1090.

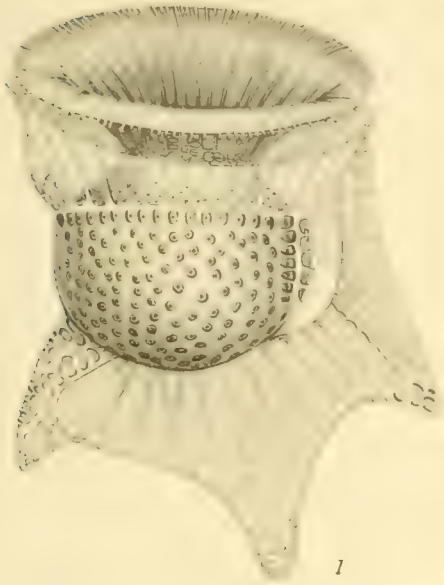
Fig. 5. The same specimen, right lateral view. Observe the adherence of right sulcal list to left sulcal list. × 1090.

Fig. 6. *Ornithocercus carolinae* Kofoid, dorsal view; type specimen. Station 4730 (300–0 fathoms). × 695.

Fig. 7. *Ornithocercus orbiculatus* Kofoid and Michener, right lateral view; type specimen. Station 4617 (300–0 fathoms). × 525.

Fig. 8. *Ornithocercus quadratus* Schütt, f. *schütti*, nov., right lateral view; right sulcal list omitted; type specimen. Station 4737 (100–0 fathoms). × 525.

Fig. 9. *Ornithocercus steini* Schütt, *s. str.*, right lateral view, right sulcal list omitted. Station 4737 (300–0 fathoms). × 525.



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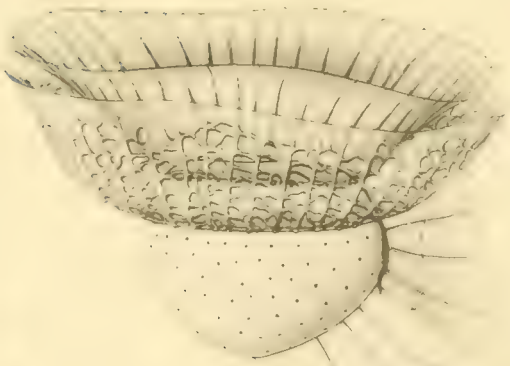

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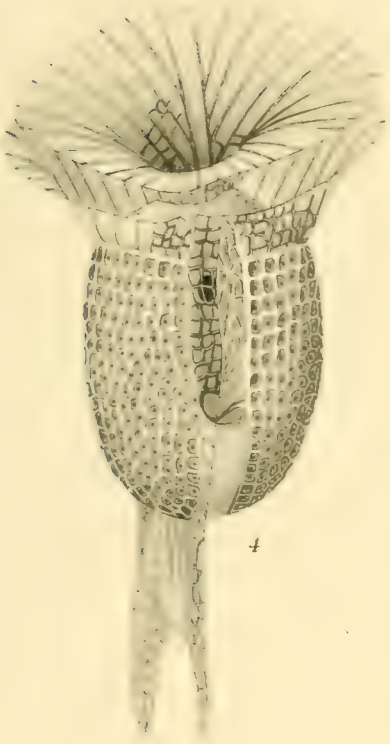

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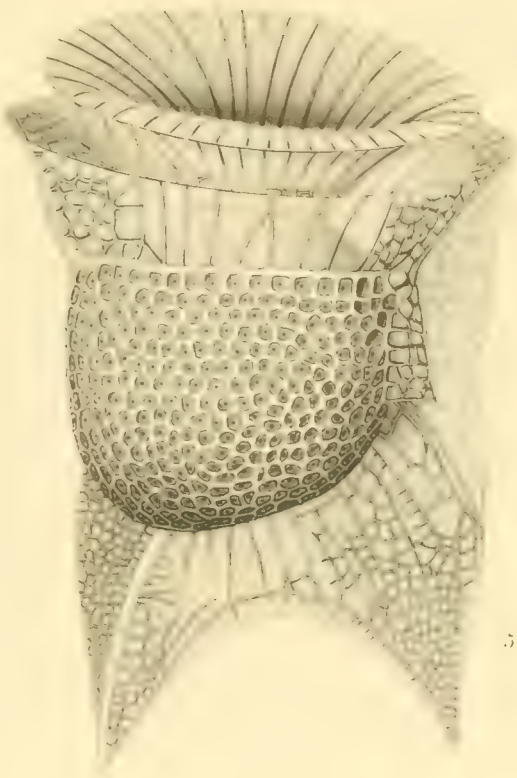

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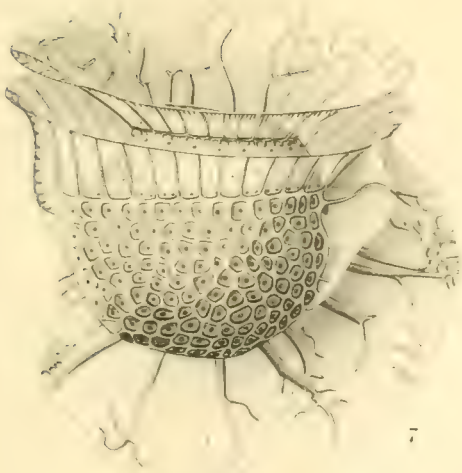

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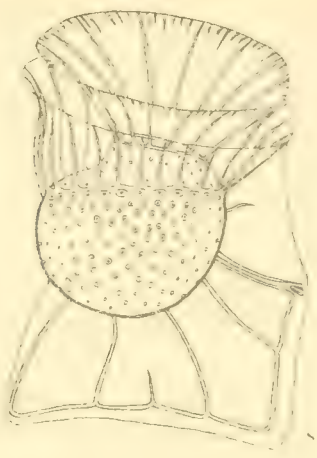

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PLATE 18.

PLATE 18.

Fig. 1. *Ornithocercus heteroporus* Kofoid, oblique ventral view; right sulcal list omitted. Observe the two kinds of pores. Type specimen. Station 4699 (300–0 fathoms). × 1090.

Fig. 2. *Ornithocercus* sp. indet., lateral view of two schizonts adhering to each other, following fission, by means of dorsal bridge, and both strikingly smaller than parent. Edges of old posterior half of left sulcal list (of specimen to the right) show signs of resorption. Station 4737 (100–0 fathoms). × 525.

Fig. 3. *Ornithocercus heteroporus* Kofoid, right lateral view; right sulcal list omitted. Observe the two kinds of pores. Type specimen. Station 4699 (300–0 fathoms). × 1090.

Fig. 4. *Ornithocercus thurni* (Schmidt), two schizonts in oblique ventrolateral view. Old lists not resorbed in fission. In specimen to the right the posterior half of left sulcal list still undeveloped. In specimen to the left the anterior half of this list partly developed. Station 4740 (300–0 fathoms). × 525.

Fig. 5. *Ornithocercus thurni* (Schmidt), posterior view of the two schizonts represented by figure 4; showing bridge of adherence on dorsal side. × 525.

Fig. 6. *Ornithocercus thurni* (Schmidt), oblique dorsal view of the two schizonts represented by figures 4, 5; showing bridge of adherence, and that cingular lists of new valves are still undeveloped.

Fig. 7. *Ornithocercus* sp. indet., posterior view of the two schizonts represented by figure 2; showing length of bridge of adherence and lack of differentiation of new valves. Station 4737 (100–0 fathoms). × 525.

Fig. 8. *Ornithocercus* sp. indet., right lateral view of specimen, the depth of which has been reduced by unequal fission. Station 4701 (300–0 fathoms). × 1090.

Fig. 9. *Ornithocercus* sp. indet., right lateral view, showing a stage in the kind of unequal fission that results in specimens of the elongated type represented in figure 8. On dorsal side of body remains of thecae of parent and grandparent are still present. Theca of grandparent was subcircular in lateral outline as in most species of this genus. Left sulcal list is being resorbed posterodorsally. Station 4604 (surface). × 865.

Fig. 10. *Ornithocercus* sp. indet., ventral view of specimen represented by figure 8. Station 4701 (300–0 fathoms). × 1090.

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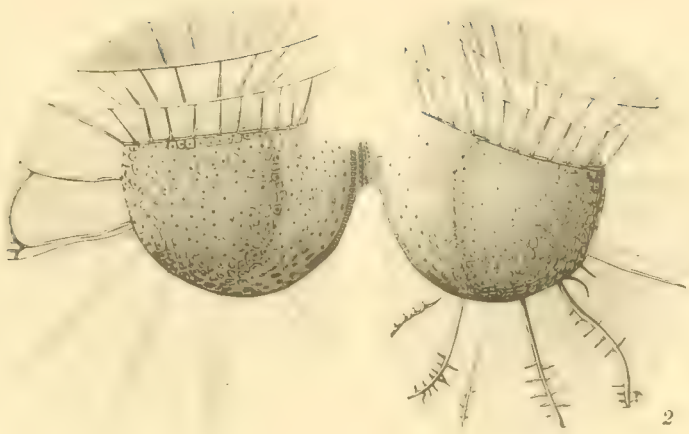

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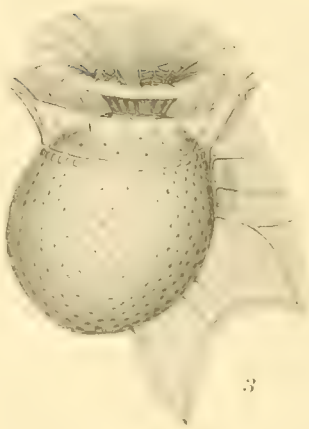

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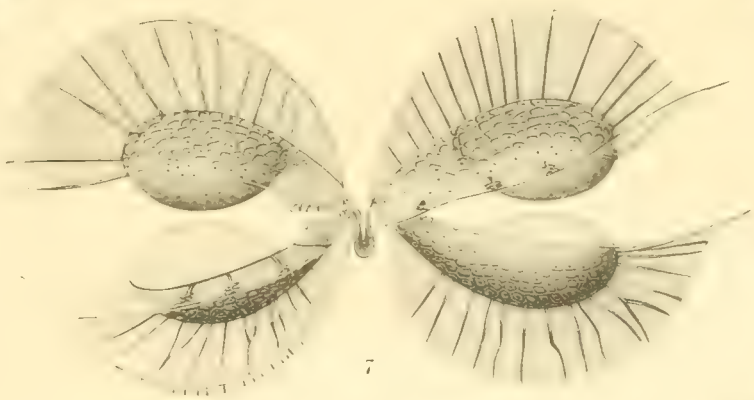

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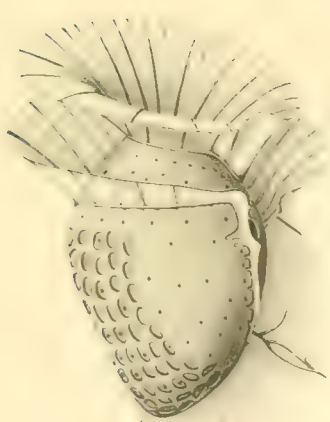

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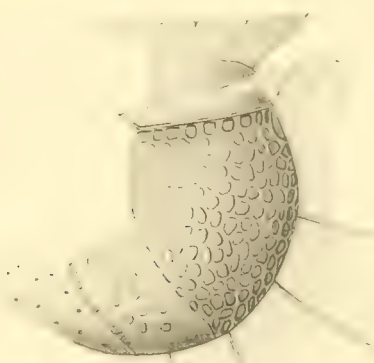

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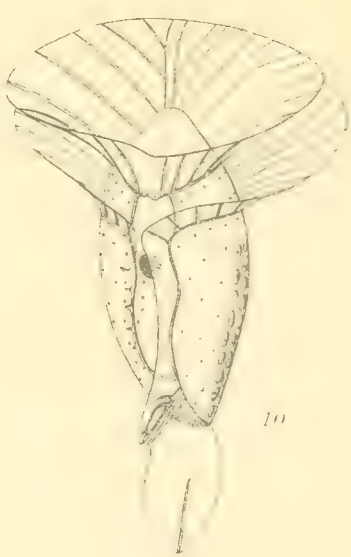

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A. B. Stone, lith. Bos.

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PLATE 19.

PLATE 19.

Fig. 1. *Parahistioneis garretti* (Kofoid), right lateral view, right sulcal list omitted; type specimen. Station 4732 (300–0 fathoms). × 1090.

Fig. 2. *Parahistioneis karsteni* (Kofoid and Michener), right lateral view, right sulcal list omitted; type specimen. Station 4619 (Salpa). × 1090.

Fig. 3. *Parahistioneis paraformis*, sp. nov., right lateral view, slightly tilted ventrally; right sulcal list omitted; type specimen. Station 4724 (300–0 fathoms). × 1090.

Fig. 4. *Parahistioneis diomedeae* (Kofoid and Michener), ventral view; type specimen. Station 4699 (300–0 fathoms). × 1090.

Fig. 5. The same specimen, right lateral view. × 1090.

Fig. 6. *Parahistioneis paraformis*, sp. nov., ventral view; type specimen. Station 4724 (300–0 fathoms). × 1090.

Fig. 7. *Parahistioneis reticulata* (Kofoid), right lateral view, right sulcal list omitted; type specimen. Station 4699 (300–0 fathoms). × 1090.

Fig. 8. *Parahistioneis rotundata* (Kofoid and Michener), right lateral view. The border on the dorsal side indicates that the specimen was megacytic. Type specimen. Station 4720 (Salpa). × 2180.

Fig. 9. The same specimen, ventral view. The dotted line indicates the thickness of the thecal wall. × 2180.

Fig. 10. *Parahistioneis reticulata* (Kofoid), ventral view; type specimen. Station 4699 (300–0 fathoms). × 1090.

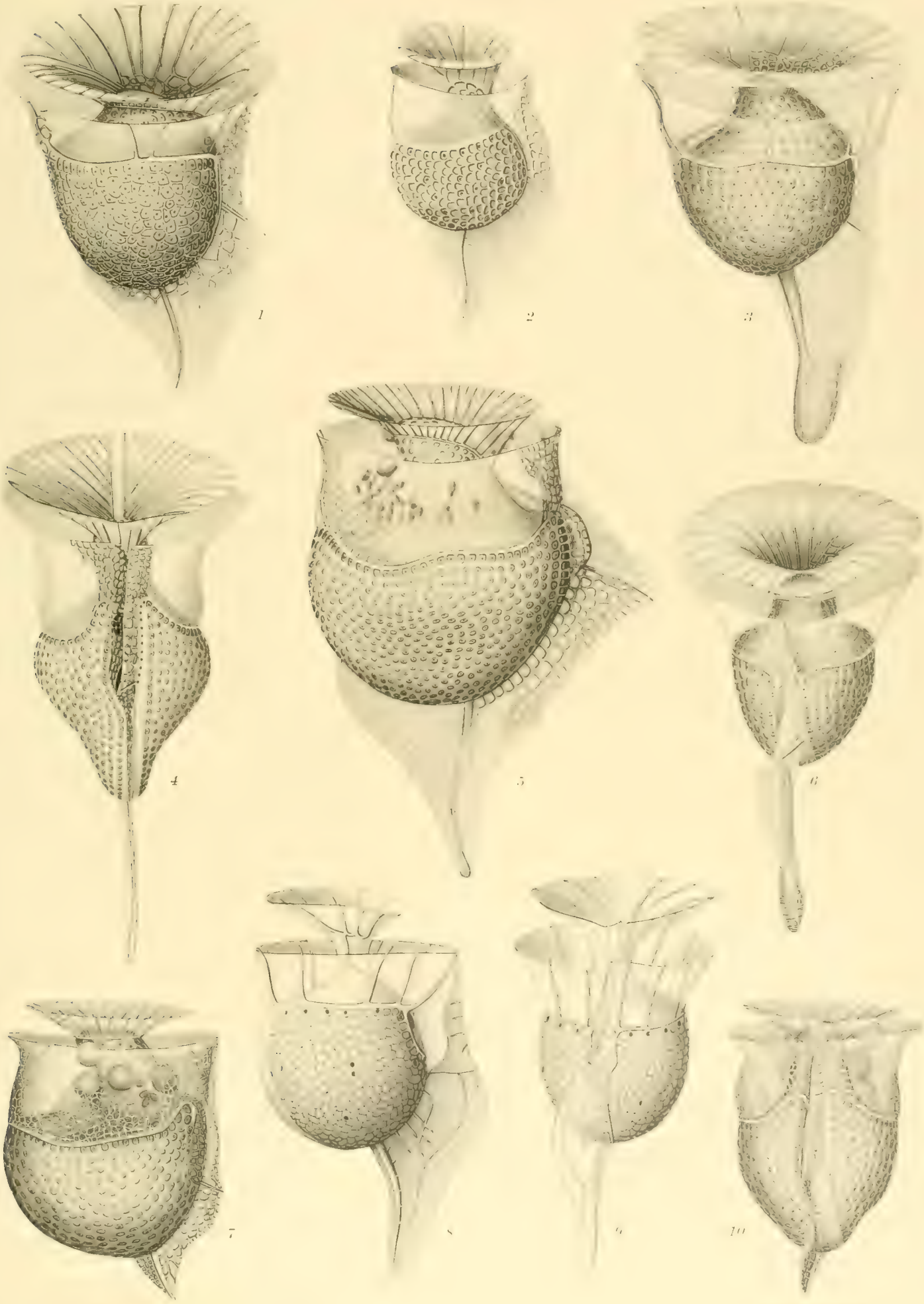


PLATE 20.

PLATE 20.

Fig. 1. *Histioneis paulseni* Kofoid, right lateral view; type specimen. Station 4711 (300–0 fathoms). × 1090.

Fig. 2. The same specimen, ventral view. × 1090.

Fig. 3. *Histioneis costata* Kofoid and Michener, right lateral view; type specimen. Station 4604 (surface). × 1090.

Fig. 4. *Histioneis hyalina* Kofoid and Michener, right lateral view; type specimen. Station 4720 (surface). × 1090.

Fig. 5. *Histioneis longicollis* Kofoid, ventral view; type specimen. Station 4711 (300–0 fathoms). × 1090.

Fig. 6. *Histioneis striata* Kofoid and Michener, right lateral view; type specimen. Station 4720 (Salpa). × 1640.

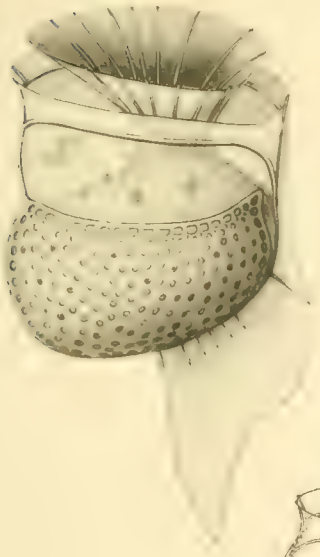
Fig. 7. *Histioneis elongata* Kofoid and Michener, ventral view of body, showing canal formed by right sulcal list, opening anteriorly into girdle and posteriorly at fission rib of left sulcal list; type specimen. Station 4722 (300–0 fathoms). × 2180.

Fig. 8. *Histioneis pacifica*, sp. nov., right lateral view; type specimen. Station 4741 (Salpa). × 1090.

Fig. 9. *Histioneis reginella* Kofoid and Michener, right lateral view; type specimen. Station 4681 (300–0 fathoms). × 1640.

Fig. 10. *Histioneis costata* Kofoid and Michener, ventral view; type specimen. Station 4604 (surface). × 1090.

Fig. 11. *Histioneis reginella* Kofoid and Michener, ventral view; type specimen. Station 4681 (300–0 fathoms). × 1640.



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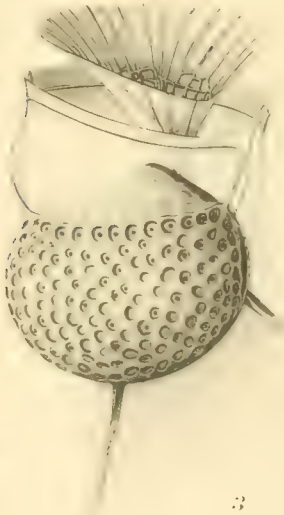

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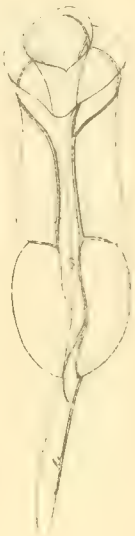

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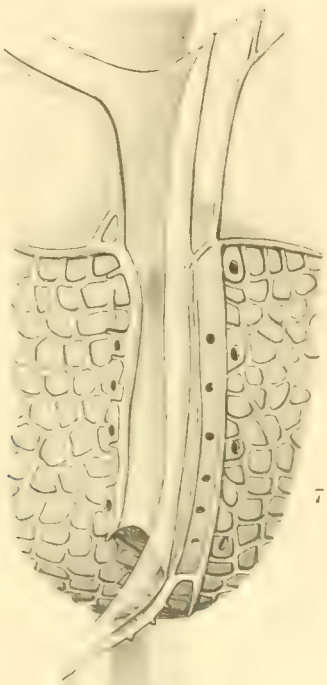

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PLATE 21.

PLATE 21.

Fig. 1. *Histioneis carinata* Kofoid, ventral view; type specimen. Station 4724 (300–0 fathoms). × 1090.

Fig. 2. *Histioneis mitchellana* Murray and Whitting, left lateral view. The transverse flagellum displaced, encircles the anterior cingular list in the wrong direction. Station 4730 (300–0 fathoms). × 1090.

Fig. 3. *Histioneis navicula* Kofoid, ventral view; type specimen. Station 4734 (300–0 fathoms). × 1090.

Fig. 4. *Histioneis pulchra* Kofoid, ventral view; type specimen. Station 4730 (300–0 fathoms). × 695.

Fig. 5. *Histioneis longicollis* Kofoid, right lateral view; type specimen. Station 4711 (300–0 fathoms). × 1090.

Fig. 6. *Histioneis navicula* Kofoid, right lateral view; type specimen. Station 4734 (300–0 fathoms). × 1090.

Fig. 7. *Histioneis pulchra* Kofoid, right lateral view; type specimen. Station 4730 (300–0 fathoms). × 695.

Fig. 8. *Histioneis carinata* Kofoid, right lateral view; type specimen. Station 4724 (300–0 fathoms). × 1090.

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PLATE 22.

PLATE 22.

Fig. 1. *Histioneis josephinae* Kofoid, oblique ventral view; type specimen. Station 4699 (300–0 fathoms). × 935.

Fig. 2. The same specimen, right lateral view. × 935.

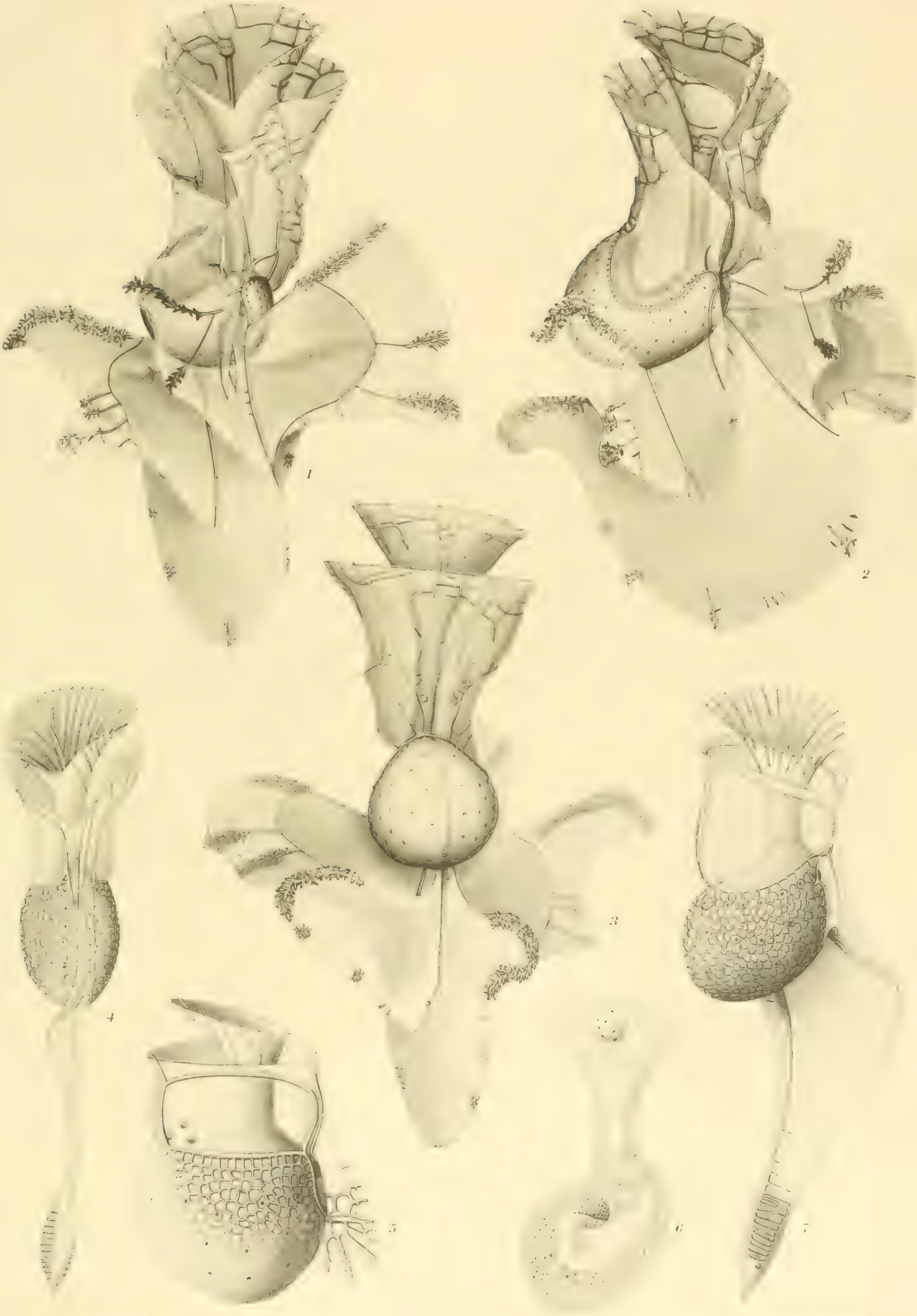
Fig. 3. The same specimen, dorsal view. × 935.

Fig. 4. *Histioneis elongata* Kofoid and Michener, ventral view; type specimen. Station 4722 (300–0 fathoms). × 1090.

Fig. 5. *Histioneis inclinata* Kofoid and Michener, right lateral view; type specimen. Station 4720 (Salpa). × 2180.

Fig. 6. *Histioneis elongata* Kofoid and Michener, body and anterior cingular list in right lateral view, showing the small, round nucleus and a large pusule. Round body in cingular list of unknown nature. Station 4722 (300–0 fathoms). × 1090.

Fig. 7. The same specimen, right lateral view. × 1090.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7

PLATE 23.

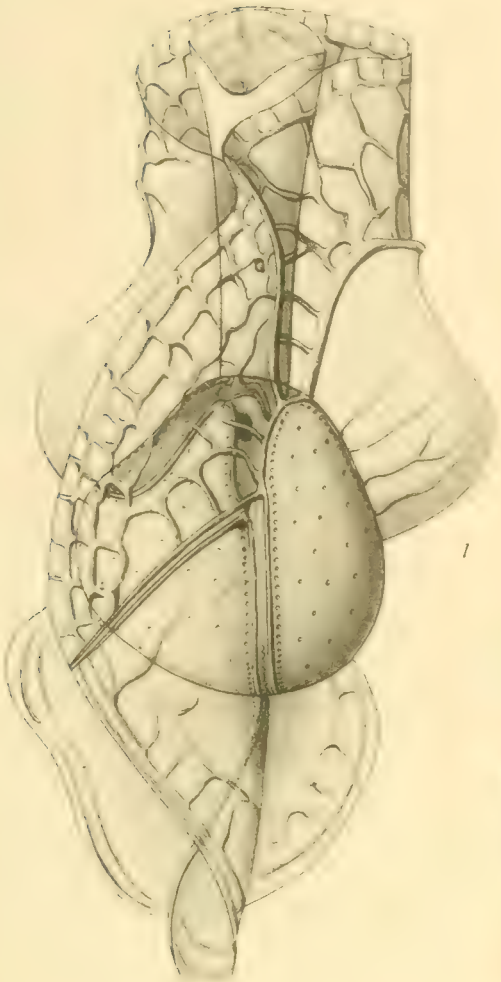
PLATE 23.

Fig. 1. *Histioneis hippoperoides* Kofoid and Michener, ventral view; type specimen. Station 4590 (300–0 fathoms). × 1310.

Fig. 2. *Histioneis pulchra* Kofoid, left lateral view, showing colors of living specimen. Station 4734 (300–0 fathoms). × 630.

Fig. 3. *Histioneis hippoperoides* Kofoid and Michener, right lateral view; type specimen. Station 4590 (300–0 fathoms). × 1310.

Fig. 4. *Histioneis josephinae* Kofoid, right lateral view, showing colors of living specimen. Station 4699 (300–0 fathoms). × 1125.



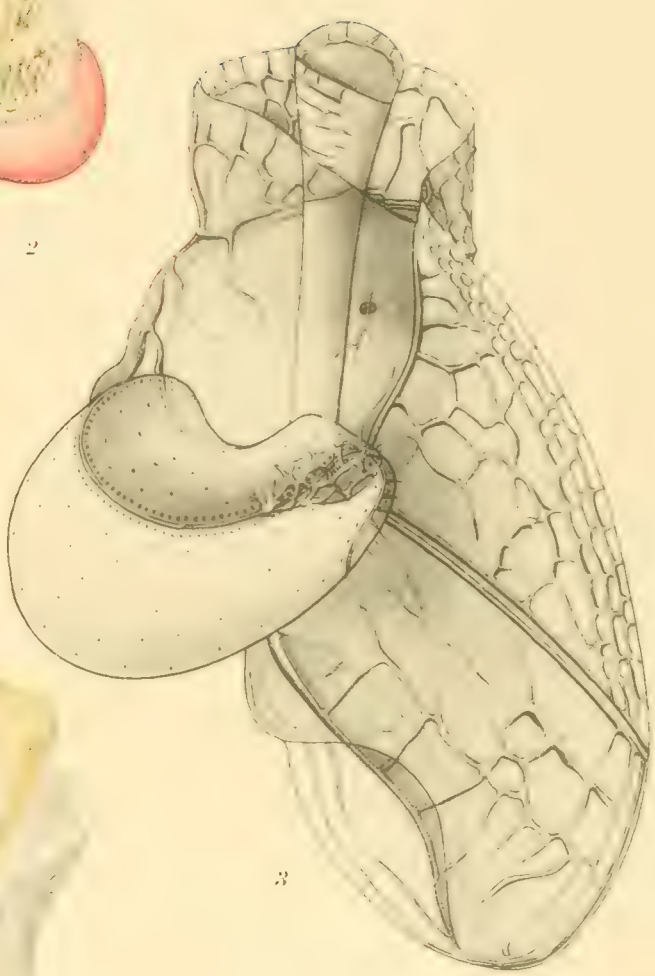
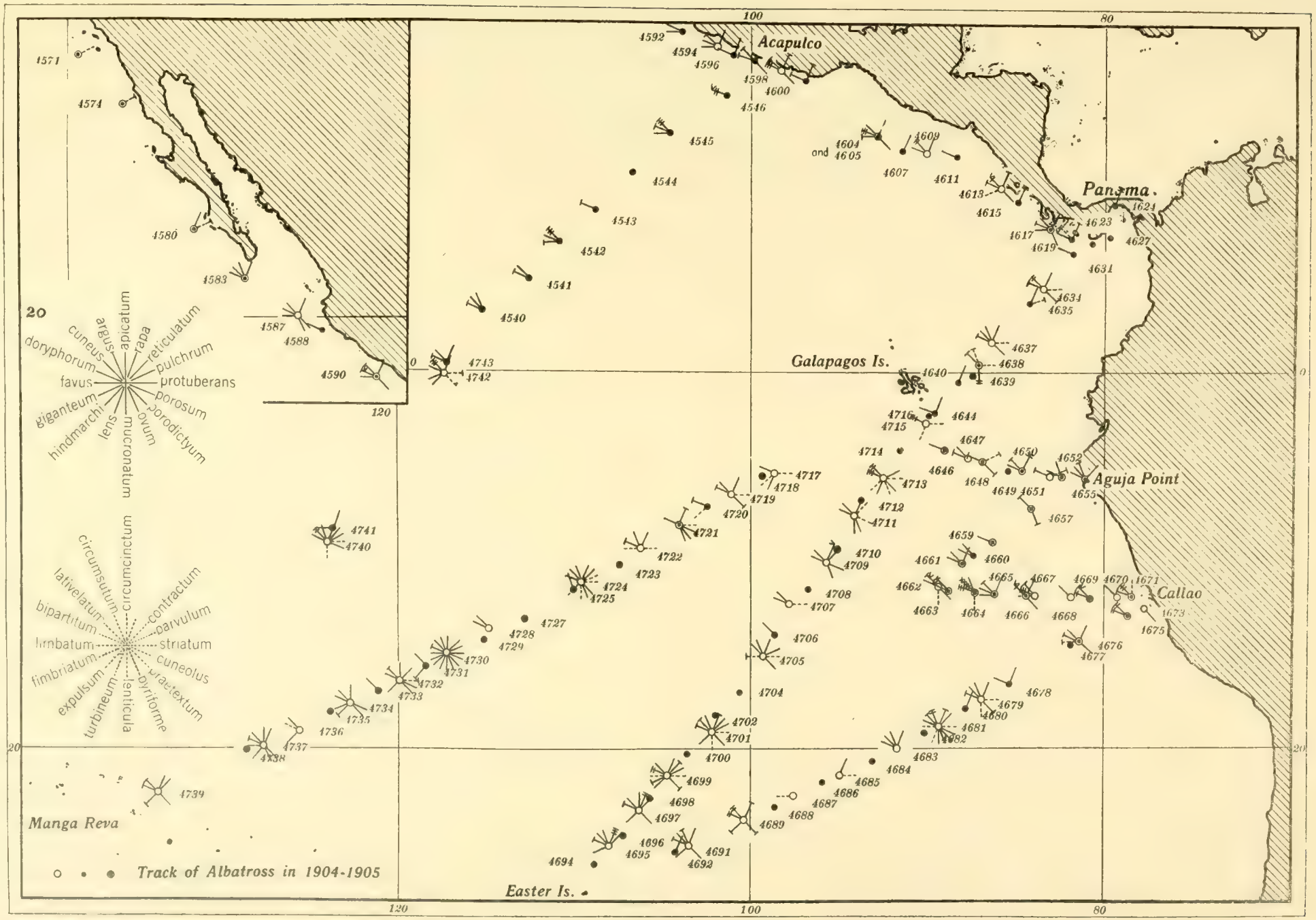


PLATE 24.

PLATE 24.

Distribution of the species of Phalacroma.

All record stations are marked by circles on the lines of the route. Solid circles indicate surface hauls; open circles, vertical hauls; open circles including solid circles, vertical and surface hauls at the same station. The occurrences of the species at the various stations are indicated by radii, the keys to which are to be found in the key stars on the left side of the chart. The frequencies are indicated by Roman numerals at the distal ends of the radii; these numerals should be read from the distal toward the proximal end of the radius. Absence of Roman numerals indicates that the species were "present" (*i.e.*, frequency of less than 1%).


100
80
120
0
20
Acapulco
Panama
Galapagos Is.
Aguja Point
Callao
Manga Reva
Easter Is.
Track of Albatross in 1904-1905
4592
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apicatum
argus
cuneus
rapa
reticulatum
doryphorum
pulchrum
favus
protuberans
porosum
giganteum
porodictyum
hindmarchi
lens
ovum
mucronatum

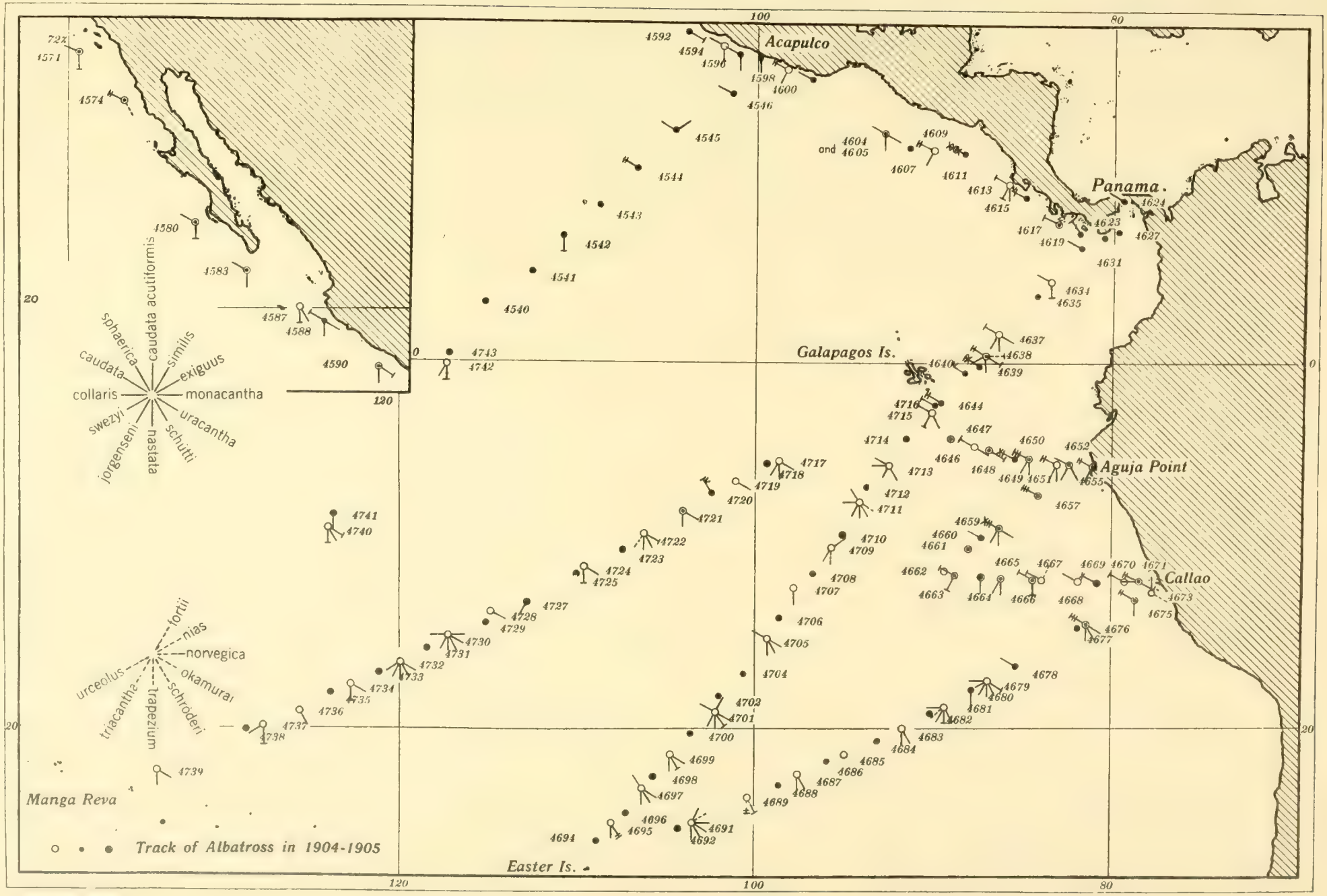
circumcinctum
circumsutum
lativelatum
contractum
bipartitum
parvulum
limbatum
striatum
fimbriatum
cuneolus
expulsum
urceolus
turbineum
reticulum
pyriforme

PLATE 25.

PLATE 25.

Distribution of the species of Dinophysis.

The explanations of the symbols will be found in the explanation to Plate **24**.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Manga Reva
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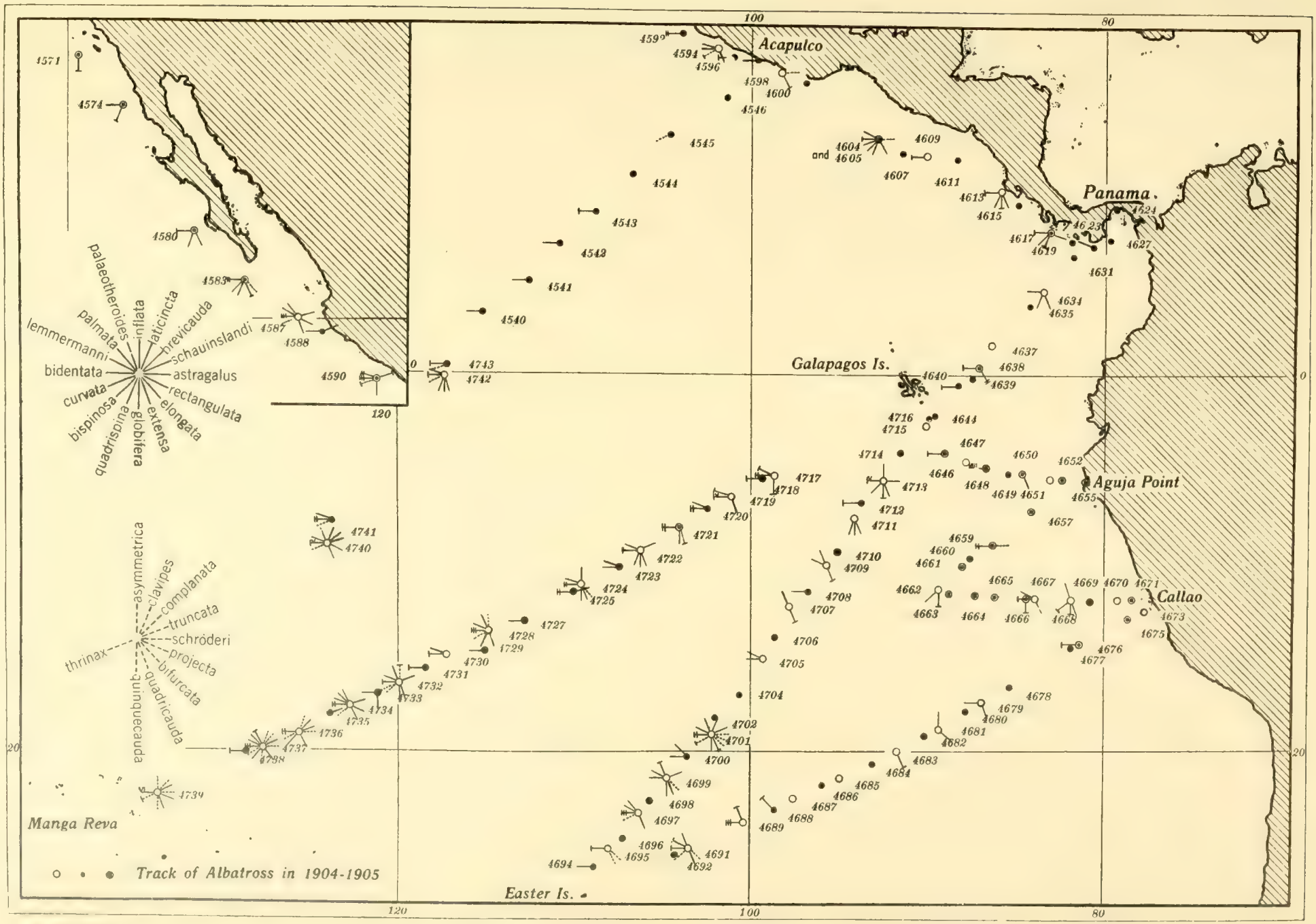
Track of Albatross in 1904-1905
caudata acutiformis
sphaerica
caudata
collaris
swezyi
jorgenseni
similis
exiguus
monacantha
uracantha
schutti
nastata
tortii
nias
norvegica
okamurai
schröderi
trapezium
triacantha
urceolus

PLATE 26.

PLATE 26.

Distribution of the species of Amphisolenia.

The explanations of the symbols will be found in the explanation to Plate 24.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Aguja Point
Callao
Manga Reva
Easter Is.
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palaeotheroides
inflata
palmata
laticincta
brevicauda
lemmermanni
schauinslandi
bidentata
astragalus
curvata
rectangulata
bispinosa
elongata
quadrispina
extensa
globifera
asymmetrica
clavipes
complanata
truncata
thrinax
schröderi
projecta
bifurcata
quadricauda
quinquecauda
and
Track of Albatross in 1904-1905

PLATE 27.

PLATE **27**.

Distribution of the species of Triposolenia.

The explanations of the symbols will be found in the explanation to Plate **24**.

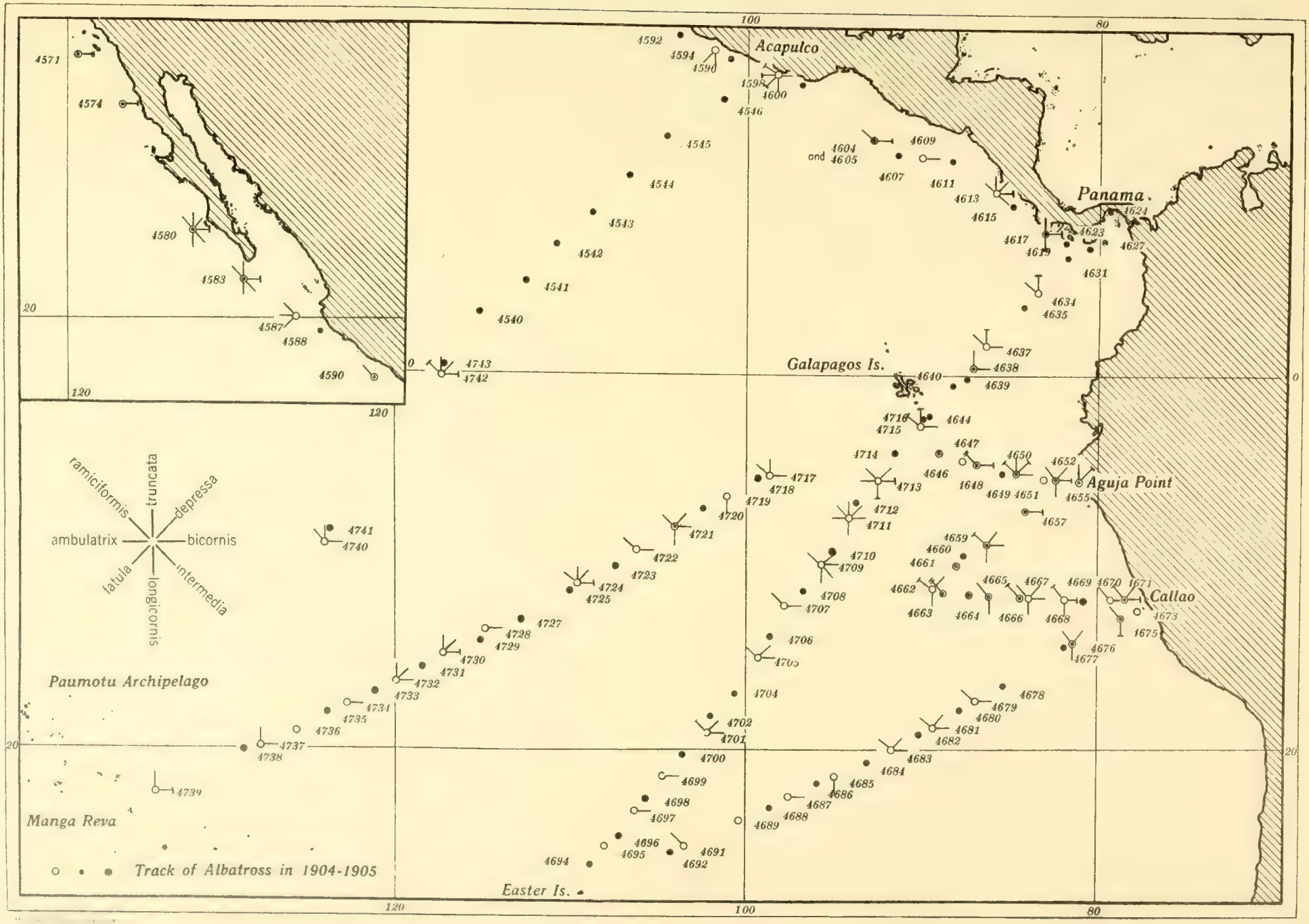
Acapulco
Panama
Galapagos Is.
Aguja Point
Callao
Paumotu Archipelago
Manga Reva
Easter Is.
ramiciformis
truncata
depressa
ambulatrix
bicornis
fatula
intermedia
longicornis
Track of Albatross in 1904-1905
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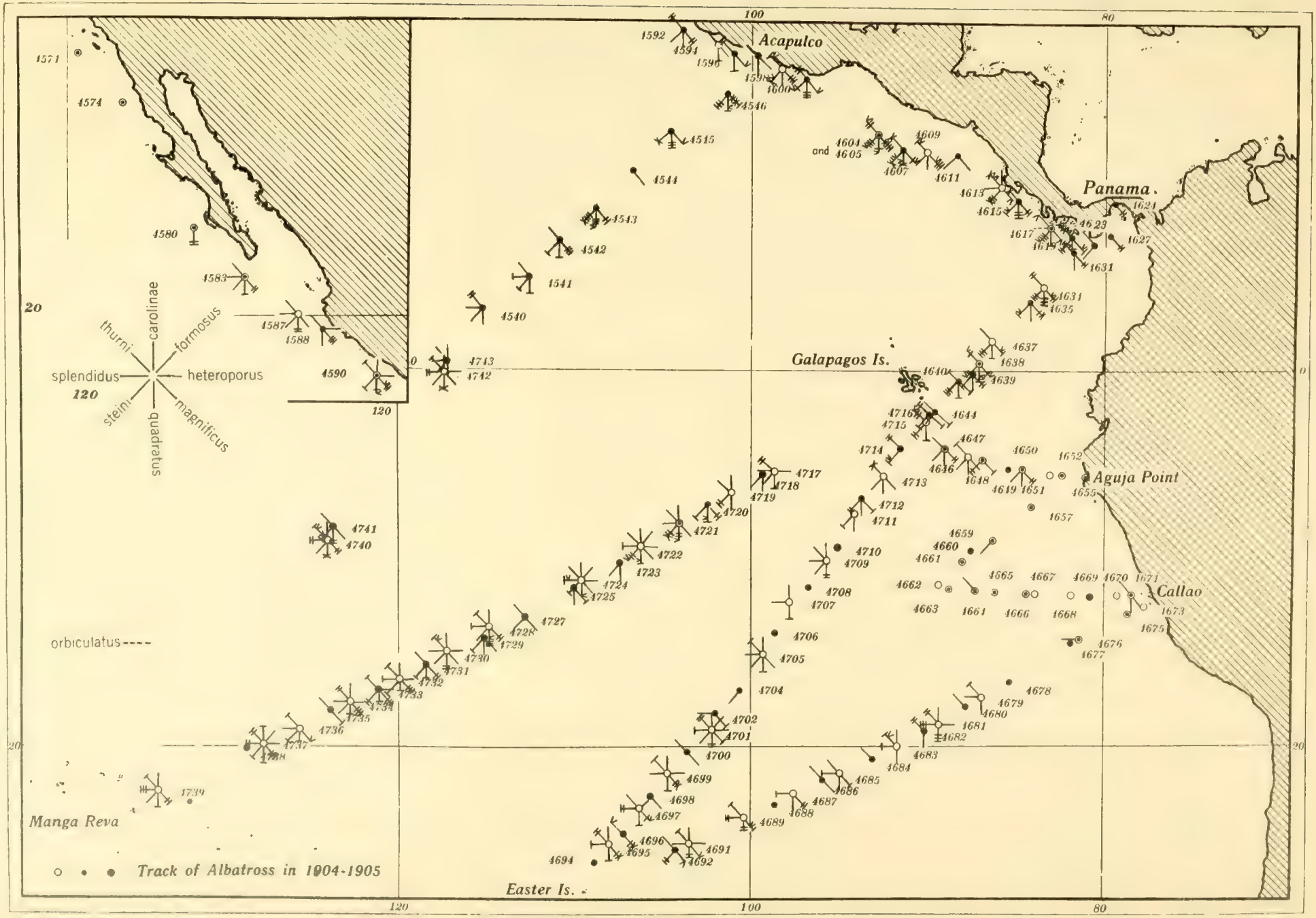
PLATE 28.

PLATE **28**.

Distribution of the species of Ornithocercus.

The explanations of the symbols will be found in the explanation to Plate **24**.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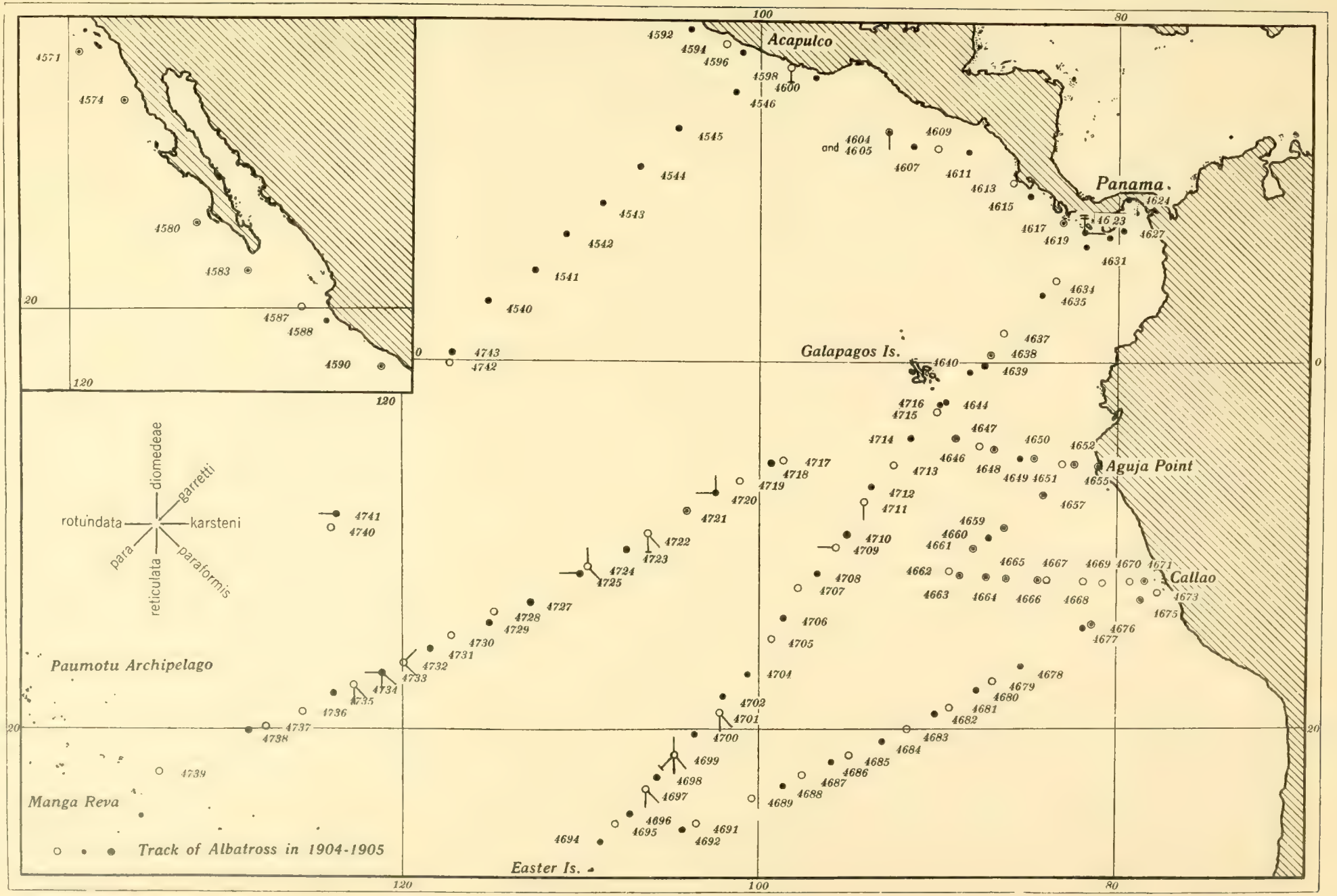
formosus
thurni
splendidus
heteroporus
stemi
quadratus
magnificus
orbiculatus
and
Track of Albatross in 1904-1905

PLATE 29.

PLATE **29**.

Distribution of the species of Parahistioneis.

The explanations of the symbols will be found in the explanation to Plate **24**.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Aguja Point
Callao
Paumotu Archipelago
Manga Reva
Easter Is.
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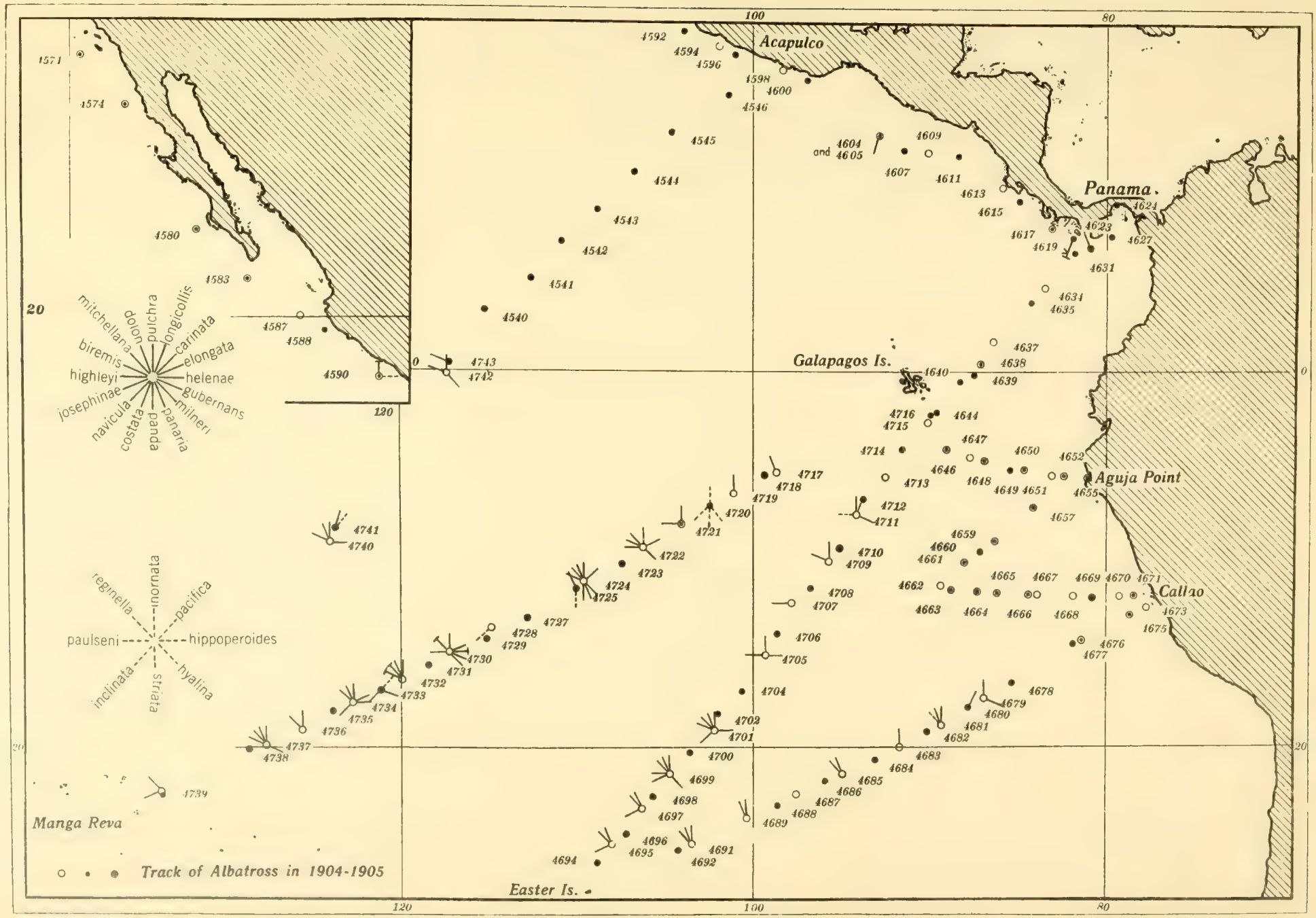
diomedeae
garretti
rotundata
karsteni
para
paraformis
reticulata
Track of Albatross in 1904-1905

PLATE 30.

PLATE 30.

Distribution of the species of Histioneis.

The explanations of the symbols will be found in the explanation to Plate 24.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Callao
Manga Reva
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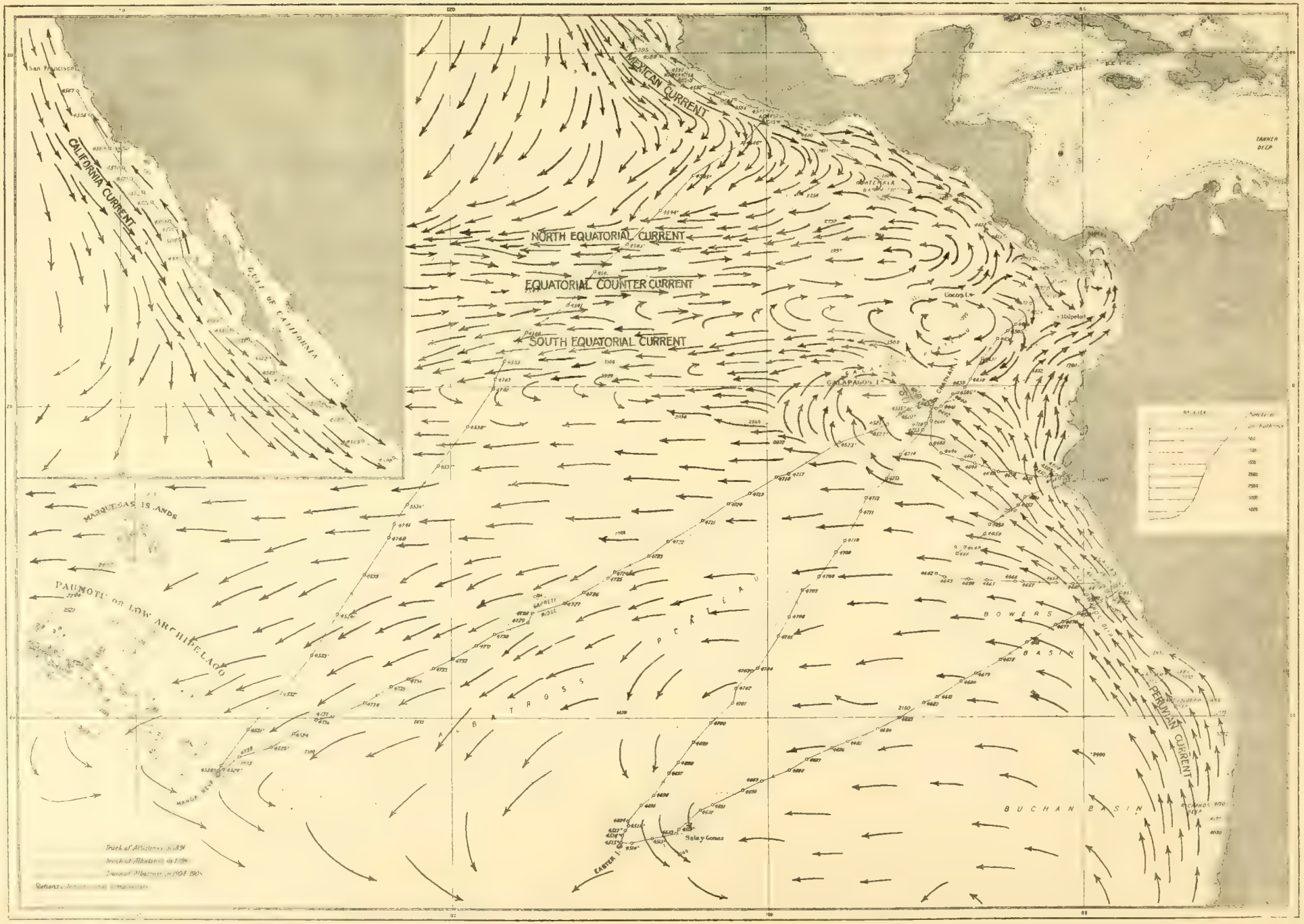
mitchellana
dolon
pulchra
longicollis
carinata
elongata
helenae
gubernans
milneri
panaria
apuea
costata
navicula
josephinae
highleyi
biremis
reginella
inornata
pacifica
hippoperoides
hyalina
striata
inclinata
paulseni
Track of Albatross in 1904-1905

PLATE 31.

PLATE 31.

Current chart.

This chart represents the prevalent currents in the Eastern Pacific during the two winter quarters. It is based on the combined data contained in the "Quarterly Current Charts for the Pacific Ocean" published by the Hydrographic Department, Admiralty, London, and in the Pilot Charts issued quarterly by the Hydrographic Office of the United States Navy.


MEXICAN CURRENT
CALIFORNIA CURRENT
NORTH EQUATORIAL CURRENT
EQUATORIAL COUNTER CURRENT
SOUTH EQUATORIAL CURRENT
PERUVIAN CURRENT
GULF OF CALIFORNIA
GALAPAGOS
MARQUESAS ISLANDS
PAUMOTU OR LOW ARCHIPELAGO
BOWERS BASIN
BUCHAN BASIN
ALBATROSS PLATEAU
GARRETT RIDGE
EASTER I.
Salay Gomez
TANNER DEEP
Cocos I.
San Francisco

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